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ORIGINAL ARTICLES.

On the Occurrence of the Marine Oligocene in Palestine.

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(PLATES XVI–XVIII.)

Introduction.

THIS paper deals with a series of fossils from two localities in the coastal plain of Palestine sent to me by Mr. G. S. Blake, Geological Adviser to the Palestine Government. It is possible from their study to establish for the first time the presence of Oligocene beds in that country.

Most of the specimens come from a quarry opened a few years ago about 1 km. south-east of the railway station at Ramle, on the line from Jerusalem to Jaffa. The section seen here consists of about 10 metres of yellow limestone with minor bands of white chalky limestone and yellow marls. In places the limestone is crowded with large and small foraminifera, and it also contains mollusca, brachiopoda, echinoidea, polyzoa, and algae. Well-preserved *Pecten* and *Ostrea* shells may be extracted from the softer patches, but other molluscan fossils consist mostly of the moulds of the original shells. These limestone beds are underlain by grey marls with foraminifera and occasional small shells ; a boring has penetrated these marls to a depth of 50 metres without reaching their base. Mr. Blake informs me that recent investigations in the neighbourhood and on the foraminifera contained in the marls indicate that the superposition is not a normal one, the marls being, in fact, much younger than the limestone.

The second locality is some 40 km. south of Ramle, on the road from Beit Jibrin to El Qubeibeh, where a slightly sandy detrital limestone with foraminifera is overlain by a more marly or chalky limestone with hard beds which contain abundant foraminifera, together with mollusca and other fossils. There are no other good exposures of these limestone beds in the district, but a certain amount of information as to their extent has been obtained by Mr. Blake from boreholes and will, it is hoped, be eventually published by him.

Specimens of foraminiferal limestone from El Qubeibeh were first sent to me by Mr. Blake early in 1925. These were examined in thin section by the late Mr. R. B. Newton and were found to contain the genus *Lepidocyclina* ; shortly afterwards this was also identified in material from Ramle. This determination was first recorded by Mr. Blake (1928, p. 20)[1] in an official report on the geology of Palestine and the probability of a Miocene age suggested. In a second official report (1930, pp. 6, 14), following confirmation of the determination of *Lepidocyclina* by Professor A. Morley Davies, Mr. Blake referred to the beds as Oligocene or Miocene. Foraminifera from Ramle and El Qubeibeh have since been studied by Messrs. D. A. Greig and F. R. S. Henson, who have identified several species of *Lepidocyclina*, including *L.* (*Eulepidina*) *dilatata* (Michelotti) and *L.* (*Nephrolepidina*) *tournoueri* Lemoine and Douvillé, among the rich suite of forms represented. Their work is not yet published.

The mollusca which had been sent to me from time to time, mainly from the Ramle quarry, were first studied in detail a few months ago, and the Oligocene affinities of the fauna became obvious. My colleague Dr. H. D. Thomas very kindly undertook a careful examination of the foraminiferal rock in the hope of discovering nummulites which would confirm the molluscan evidence. With the assistance of Mr. R. H. Spires, he has been successful in isolating a number of specimens of a small form which is closely related to, if not identical with, *Nummulites boucheri* de la Harpe, the megalospheric form of *N. vascus* Joly and Leymerie, a well-known Oligocene species. Compared with *Lepidocyclina*, which occurs in profusion, these nummulites are scarce and inconspicuous.

It should be mentioned that Professor M. Blanckenhorn paid a visit to the two localities in 1930 and was struck with the resemblance which certain of the fossils appeared to have to species from near Aintab, in northern Syria, which he (1890) had described and referred to the Lower Eocene. In a review of recent work on the geology of Palestine, Professor Blanckenhorn (1931, pp. 20, 21) therefore maintained that the beds at Ramle and El Qubeibeh should be referred to the same period. Professor Blanckenhorn has very kindly sent me some of the specimens collected by him, and it has been possible to demonstrate that the foraminifera from Ramle referred by him (loc. cit.) to the Lower Eocene species *Nummulites lucasanus* Defrance var. *granulata* de la Harpe belong, in fact, to the genus *Lepidocyclina*. A *Cardita* collected at El Qubeibeh by Professor Blanckenhorn and mentioned in his paper proves to belong to a well-known Oligocene species, *C. arduini* Brongniart (see p. 350). Professor Blanckenhorn informs me that he now agrees that the beds should be referred to the Oligocene.

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[1] See p. 353 for a list of works to which reference is made.

The present paper deals only with the molluscan fossils and with the single species of *Nummulites*, for help in the study of which I am greatly indebted to my colleague Dr. H. D. Thomas. It is hoped that Messrs. Greig and Henson will be able to publish the results of their work on the rest of the foraminiferal fauna in due course. Dr. Thomas hopes eventually to publish an account of the polyzoa.

AGE OF THE BEDS.

Apart from the evidence of the mollusca, the presence of small nummulites of the *N. vascus* group in association with *Lepidocyclina tournoueri*, *L. dilatata*, and other species of this genus definitely indicates that the beds should be referred to the Oligocene. *N. vascus* itself ranges throughout the Oligocene, as does also *L. tournoueri*; *L. dilatata* first appears in Middle Oligocene (Rupelian) times. In Liguria, Venetia, and southern France, foraminiferal beds of Rupelian age still contain nummulites in some abundance and variety,[1] while Upper Oligocene (Chattian) beds contain only rare and inconspicuous nummulites, with a profusion of *Lepidocyclina*. The evidence of the foraminifera thus appears to indicate that the beds in Palestine are of Upper Oligocene age.

The mollusca from Ramle include eleven forms which have been referred definitely to described species. All of these occur in the Oligocene of northern Italy, where their distribution may be tabulated as follows (L, Liguria; T, Trentino; V, Venetia):—

	U. Eocene.	*L. Olig.*	*M. Olig.*	*U. Olig.*	*Miocene.*
Ficus condita . . .	—	V	L, V	T, V	T, V
Xancus episomus . .	—	—	L	—	—
Modiolus incomptus . .	—	—	L	—	—
Ostrea flabellulaeformis .	V	V	—	—	—
Ostrea gigantica . .	V	V	L, V	L	—
Pecten arcuatus . .	V	V	L, V	L, T, V	—
Chlamys deleta . .	—	V	L, V	L, V	—
Chlamys quinquepartita .	—	—	L	—	—
Cardita arduini . .	—	V	L, V	T, V	—
Lucina rollei . . .	—	—	L	L	—
Meretrix ovisimilis . .	—	—	—	V	—

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[1] According to Rovereto (1914, p. 19) the Rupelian beds at Dego, a well-known Ligurian fossil locality, contain *N. intermedius* d'Arch., *N. garansensis* Joly and Leym., *N. fichteli* Mich., *N. miocontortus* Tellini, *N. rosai* Tellini, *N. vascus* Joly and Leym., and *N. tournoueri* de la Harpe. Rovereto refers these beds to the Lower Oligocene (Lattorfian), but it has been pointed out by Haug (1911, p. 1485) and H. Douvillé (1925, p. 63) that the horizons assigned by him are too low, his "Lattorfian" beds being Rupelian and his "Rupelian" beds Chattian.

It can be readily seen from this table that the molluscan fauna has closest affinity with that of the Middle Oligocene beds of Liguria, where several rich fossil localities have yielded the material described in Rovereto's monographs (1900, 1914). In view, however, of the foraminiferal evidence in favour of a Chattian age, I am not inclined to attach too much importance to the fact that the molluscan fauna appears more closely related to one of a slightly older horizon. Of the four Ramle species which have not been found in Chattian beds in Italy, three belong to the genera *Modiolus*, *Ostrea*, and *Chlamys*, which can seldom be used for very exact correlation ; the fourth, *Xancus episomus*, has been found in Sardinia in beds referred to the Aquitanian, although I suspect that their true horizon will prove to be somewhat lower. On the whole, therefore, I consider that the evidence at present available favours an Upper Oligocene age for the beds in Palestine, although the possibility of a Middle Oligocene age is not excluded.

THE OLIGOCENE IN NEIGHBOURING AREAS.

Until recently Oligocene rocks had not been definitely recorded from anywhere in Palestine or Syria, although Diener (1886, p. 47) long ago suggested the possibility of an Oligocene age for certain limestones of the Antilebanon and Palmyra districts. During the last few years the Oligocene has been discovered by the official French geologists in at least three districts in Syria, namely, at Jebel Bichri (between Palmyra and the Euphrates), at Jebel Abiad (north-west of Palmyra), and at Nebek (60 km. north-east of Damascus.[1] Chalky limestones with *Lepidocyclina* appear to constitute the most abundant rock-type. The molluscan fossils, if any, have not yet been recorded. Fossils (including nummulites) of Priabonian age[2] have been recorded by Blanckenhorn (1890, pp. 333, 341) from near Tab, north of Aintab, in northern Syria, and limestones with siliceous bands overlying the beds from which these were obtained have yielded corals and mollusca, the former including a well-known Oligocene species *Isastraea michelottina* (Catullo) and the latter the species *Chlamys quinquepartita* (Blanckenhorn), which is one of the forms recorded from Palestine in the present paper. Oppenheim (1917, pp. 80, 81) has already pointed out that these overlying beds are probably of Oligocene age and has also recorded a cast closely resembling that of the well-known and characteristic Oligocene species "*Natica*" *crassatina* Lamarck from Marash, still further north. The age of the beds underlying Aintab itself and to the south of the town needs further investigation. Blanckenhorn referred these to the Lower Eocene, but Oppenheim (1917, p. 78) has shown that the beds underlying the town contain the species *Thracia bellardii* Pictet, which is certainly not pre-Middle Eocene, and occurs most commonly in the Upper Eocene and Oligocene. These beds also yielded the type-specimen of *Pecten livoniani* Blanckenhorn (1890, p. 351, pl. xix, figs. 1*a*, *b*), which would be referred to the species *Chlamys miocenica* (Michelotti) were it known to come from beds of Oligocene age. It must be mentioned that Blanckenhorn (1931, p. 21) has recorded this species from Ramle, although I have not seen any specimens from there. The beds south of the town have yielded *Chlamys quinquepartita*, the type-horizon of which, as mentioned above, is probably Oligocene, and the species *Cardita aintabensis* Blanckenhorn (1890, p. 354, pl. xix, figs. 4–7), which is very close to certain varieties of *C. arduini* Brongniart, an Oligocene form recorded from Palestine in the present paper. It is thus quite possible that the Oligocene is developed at Aintab itself and to the south of the town.

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[1] Information in a letter from M. L. Dubertret to Mr. G. S. Blake. Mlle. E. David (1933) has published a note on the occurrences near Palmyra.

[2] Oppenheim (1901, p. 318) states that he has seen these nummulites and confirmed their determinations.

To the east of Syria the Oligocene beds probably extend into Iraq, but there is no published information concerning their development in that country. A short account of the Oligocene in Persia has been given by de Böckh, Lees, and Richardson (1929, pp. 99–101). Limestones with *Lepidocyclina* appear to constitute the most prevalent facies, but no records of the associated mollusca have been published.

Oligocene fossils have been described by Oppenheim (1917, pp. 74–6, 81) from Siwas, in Asia Minor, and the formation will, no doubt, be found to be developed in other parts of that area. In Cyprus the Kythrean Series has been referred to the Oligocene, but the facies differs considerably from that of the beds in Palestine. Dr. F. R. Cowper Reed (1930, p. 243) has recorded the discovery of pteropods, worm-tracks, and fucoid markings in these beds, but in the main they consist of unfossiliferous marls. Bukowski (1898, pp. 579–587) has recorded Oligocene deposits in Rhodes, and these contain, among other forms, the species *Pecten arcuatus* (Brocchi), *Ostrea* cf. *gigantica* Solander, and *Nummulites vascus*, showing that the facies is comparable to that of the beds in Palestine.

The Egyptian Oligocene differs completely from that of Palestine. In the Fayum depression the Eocene is overlain by Oligocene beds of a fluvio-marine facies. Marine mollusca are found in the uppermost beds, but these do not include any of the species now recorded from Palestine. Nowhere in Egypt are foraminiferal limestones of Oligocene age found. The Oligocene deposits of Cyrenaica have been described and their fauna discussed by Stefanini (1921, pp. 117–133). The rock is a brown or yellow limestone with foraminifera, echinoidea, mollusca, and algae, including several of the species now recorded from Palestine.

Description of the Fossils.

CEPHALOPODA.

Genus Nautilus Linné, 1758.

Nautilus sp.

Locality and Material.—Ramle, one specimen, consisting of the internal cast of the body-chamber and preceding five chambers.

Description and Remarks.—Large and inflated, measuring 135 mm. in diameter and 90 mm. in thickness at the aperture. Whorls subquadrate in cross-section, wider than high, flattened laterally and very broadly rounded ventrally. Umbilicus narrow and deep. Sutures flexuous laterally, but nearly straight where they cross the broad periphery. Siphuncle dorso-central.

N. piersantii Venzo (1933*a*, p. 203, pl. ii, figs. 4*a*, *b*) is the most similar form described from the Oligocene, but is slightly more gibbose. The Miocene species *N. allioni* Michelotti (for figures, see Bellardi, 1872, part 1, p. 20, pl. iii, figs. 1*a–d*) is comparable in shape but much smaller.

GASTROPODA.

Genus Natica Scopoli, 1777 (*sensu lato*).

" *Natica* " sp.

Pl. XVI, Figs. 7*a*, *b*.

Locality and Material.—Ramle, one internal cast.

Description and Remarks.—A depressed-ovate form, 36 mm. high and originally about 42 mm. in diameter, with a very low obtuse spire. The whorls number about four ; the profile of the last whorl is strongly and symmetrically convex.

This specimen probably belongs to the Naticidae, but its genus is uncertain. It somewhat resembles the Eocene species *Cepatia cepacea* (Lamarck), but has fewer whorls. A specimen from the Oligocene of Gaas (France) comparable in shape has been figured by Grateloup (1847, pl. iii of *Natica*, fig. 15) under the name *N. cepacea* var. *umbonata.*

Genus Globularia Swainson, 1840.

Globularia sp.

Pl. XVI, Fig. 2.

Locality and Material.—Ramle, one internal cast.

Description and Remarks.—A rather crushed specimen of a low-spired, globose species about 35 mm. in height and originally of about the same diameter. Pronounced growth-rugae occur at irregular intervals. This appears to be closely comparable to the well-known Oligocene species *G. auriculata* (Grateloup). In *G. gibberosa* (Grateloup) the aperture is more obliquely dilated.

Genus FICUS Bolten, 1798.

Ficus condita (Brongniart).

1823. *Pyrula condita* Brongniart, p. 75, pl. vi, figs. 4*a*, *b*.
1870. *Ficula condita* Fuchs, p. 187.
1891. *Ficula condita* (and vars.) Sacco, part 8, pp. 23–7, pl. i, figs. 27–32.
1897. *Ficula condita* Wolff, p. 275, pl. xxvi, fig. 10.
1900. *Pirula condita* Rovereto, p. 159.
1908. *Pyrula condita* Canestrelli, p. 134.
1933*a*. *Ficula condita* Venzo, p. 192.

Locality and Material.—Ramle, one cast retaining the impression of the external sculpture.

Distribution.—Lower Oligocene to Upper Miocene of northern Italy. Oligocene of Bavaria and northern Germany. Lower Miocene of Austria and France. Oligocene of Algeria.

Genus XANCUS Bolten, 1798.

(= TURBINELLA Lamarck, 1799.)

Xancus episomus (Michelotti).

Pl. XVI, Fig. 1.

1861. *Fusus ? episomus* Michelotti, p. 160, pl. xvi, fig. 5.
1873. *Fusus ? episomus* Manzoni, p. 13.
1884. *Turbinella episoma* Bellardi, part 4, p. 52, pl. ii, fig. 35.
1887. *Fusus ? episomus* Parona, p. 349.
1900. *Turbinella episoma* Rovereto, p. 169.
1901. *Turbinella episoma* Cossmann, vol. iv, p. 64, pl. vii, fig. 16.
1925. *Turbinella episoma* Vredenburg, p. 168.

Locality and Material.—Ramle, two internal casts.

Description and Remarks.—These specimens must have been at least 28 cm. high when complete; their anterior extremities, however, have been broken off. The acutely pointed spire occupies about one-third of the original height, and consists of high whorls with flattened sides and almost flat, sloping shoulders. The impressions of very blunt tubercles can just be discerned at the shoulder-angle. The aperture is comparatively narrow, the outer lip subvertical. The impressions of three equidistant columellar folds are clearly preserved.

Allowing for the fact that the shell is missing, so that the whorl-shoulder slopes less steeply, these casts agree well in shape with Michelotti's figure of *X. episomus*, and may, I think, be definitely referred to that species. According to Bellardi the species attains a height of 18 cm. in the Italian Oligocene. Vredenburg records a specimen 22 cm. in height from the Nari Beds (Oligocene) of India.

Distribution.—Middle Oligocene of Liguria. Oligocene of San Marino. Aquitanian (*fide* Parona, but more probably Oligocene) of Isili, Sardinia. Oligocene of India.

Genus Neoathleta Bellardi MS., Sacco, 1890.

Neoathleta sp.

Locality and Material.—Ramle, one specimen.

Description and Remarks.—An imperfect and somewhat crushed cast, originally about 23 mm. in height, with a strongly concave, subhorizontal whorl-shoulder. Twelve depressed, flat-topped spiral bands are visible on the last whorl, and two or three more were probably present on the anterior extremity, which is broken away. The spirals are crossed by axial ribs, which appear to fade away on the last whorl before the aperture is reached.

This specimen cannot be determined specifically on account of its imperfect preservation, but it is important to note that it belongs to a group of species confined to the Eocene and Oligocene. The two Italian Oligocene species *N. obliqua* Bellardi and *N. tricarinata* Bellardi (in Sacco, 1890, part 6, pp. 12, 13, pl. i, figs. 13, 14) are closely comparable, but have not the concave, subhorizontal whorl-shoulder.

LAMELLIBRANCHIA.

Genus Modiolus Lamarck, 1799.

Modiolus incomptus (Rovereto).

Pl. XVIII, Fig. 5.

1898. *Modiola incompta* Rovereto, p. 173.
1900. *Modiola incompta* Rovereto, p. 73, pl. iv, figs. 10, 10*a*.
1911. *Modiola incompta* Boussac, p. 145, pl. vii, fig. 25.
1922. *Modiola* (*Amygdalum*) *incompta* Cossmann, p. 150, pl. ix, figs. 1–3.

Locality and Material.—Ramle, one specimen.

Description and Remarks.—A crushed specimen of a *Modiolus* measuring 68 mm. in length and about 32 mm. in height, with a straight, elongate hinge-margin occupying over half the total length. It corresponds well with Rovereto's figures of *M. incomptus*. *M. philippii* Mayer-Eymar MS., Wolff (1897, p. 232, pl. xx, figs. 15, 16), from the Bavarian Oligocene, is also closely comparable; *M. incomptus* may prove to be a synonym of this Bavarian form.

Distribution.—Upper Eocene (Priabonian) of South-east France. Middle Oligocene of Liguria and Aquitaine.

Genus Ostrea Linné, 1758.

Ostrea flabellulaeformis v. Schauroth.

Pl. XVI, Figs. 3, 4.

1865. *O. flabellulaeformis* v. Schauroth, p. 198, pl. xv, fig. 1.
1865. *O. flabellula* v. Schauroth, p. 198, pl. xiv, fig. 8 (*non* Lamarck).
1900. *O. flabellulaeformis* Oppenheim, p. 125.
1900*a*. *O. flabellulaeformis* Oppenheim, p. 260.
1910. *O. flabellulaeformis* Kranz, p. 206.

Locality and Material.—Ramle, one left and two right valves.

Description and Remarks.—The left valve, which is 18 mm. long, is ornamented with prominent narrow radial ribs which sometimes divaricate and are crossed by the imbricating growth-layers. The umbo is twisted towards the posterior side. The two right valves, which are somewhat lunate in shape, are feebly convex, and are ornamented only with the rather delicate imbricating growth-layers.

The left valve agrees well with the one figured as *O. flabellula* by Schauroth (loc. cit.) and referred to *O. flabellulaeformis* by Oppenheim. In the well-known Oligocene species *O. cyathula* Lamarck the ribbing is less prominent.

Distribution.—Upper Eocene (Priabonian) and Lower Oligocene of Venetia.

Ostrea gigantica Solander.

1766. *Ostrea gigantica* Solander, in Brander, p. 36, pl. viii, fig. 88.
1897. *Gigantostrea gigantica* var. *oligoplana* Sacco, part 23, p. 14, pl. iv, figs. 6–8.
1900. *Ostrea gigantica* Oppenheim, p. 123.
1910. *Ostrea gigantica* (and forma *longirostrata*) Kranz, p. 204, pl. vi, fig. 11.
1911. *Ostrea gigantica* Boussac, p. 179, pl. viii, fig. 21; pl. ix, fig. 1.
1921. *Ostrea gigantica* var. *oligoplana* Stefanini, p. 128.
1922. *Ostrea* (*Gigantostrea*) *gigantica* Cossmann, p. 208, text-figs. 10–12; pl. xv, fig. 26.

Locality and Material.—Ramle, one specimen.

Description and Remarks.—A large, orbicular, thick-shelled oyster, 99 mm. in diameter, growing attached by the greater part of its surface to another and more eroded specimen, but revealing its interior. The ligamental area is 16 mm. in length and is slightly undercut on one side; in front of it the valve-margin is fluted. The large, deep, oval muscle-scar is almost central in position.

This specimen appears to be referable to the well-known and long-ranging species *O. gigantica*; the references given above are mainly to its occurrence in the Oligocene.

Distribution.—Lower to Upper Eocene of numerous European areas. Lower and Middle Oligocene of Venetia. Middle Oligocene of Liguria. Oligocene of S. France, Austria, Algeria, Cyrenaica, and Rhodes.

Genus PECTEN Müller, 1776.

Pecten arcuatus (Brocchi).

Pl. XVI, Fig. 6.

1814. *Ostrea arcuata* Brocchi, vol. ii, p. 578, pl. xiv, fig. 11.
1850. *Pecten michelottii* d'Archiac, p. 435, pl. xii, figs. 20, 21.
1861. *Janira fallax* Michelotti, p. 78, pl. ix, figs. 4, 5.
1861. *Janira deperdita* Michelotti, p. 79, pl. ix, figs. 6, 7.
1870. *Pecten arcuatus* Fuchs, p. 203, pl. x, figs. 38–40.
1889. *Pecten nucalis* Locard, p. 51, pl. x, fig. 2.
1897. *Pecten arcuatus* Sacco, part 24, p. 65, pl. xxi, figs. 14–30.
1900. *Pecten arcuatus* Rovereto, p. 68.
1900. *Pecten* (*Janira*) *arcuata* Oppenheim, p. 135.
1918. *Pecten arcuatus* Dollfus, p. 91, pl. viii, figs. 4, 5.
1921. *Pecten arcuatus* Stefanini, p. 128, pl. xviii, fig. 5.
1922. *Pecten arcuatus* Cossmann, p. 166, pl. x, figs. 4–8.
1933. *Pecten arcuatus* Venzo, p. 215, pl. xii, figs. 9*a*, *b*.

Locality and Material.—Ramle, one specimen.

Description and Remarks.—The inflated right valve of a small *Pecten*, 19 mm. high and 18 mm. long, ornamented with twenty rather flat-topped radial ribs separated by deep, narrow interspaces which bear extremely fine concentric threads. The auricles are missing. This specimen agrees well with the descriptions of *P. arcuatus* given by the authors cited above. Teppner (1922, p. 221), unnecessarily in my opinion, has made this species the type of a new genus *Philippia.*

Distribution.—Upper Eocene (Priabonian) to Upper Oligocene of Venetia. Middle Oligocene of Liguria. Middle and Upper Oligocene of southern France. Oligocene of Bavaria, Algeria, Tunis, Cyrenaica, and Rhodes.

Genus CHLAMYS Bolten, 1798.

Subgenus *Aequipecten* P. Fischer, 1886.

Chlamys (*Aequipecten*) *deleta* (Michelotti), forma typica.

Pl. XVII, Figs. 4*a*, *b*.

1861. *Pecten deletus* Michelotti, p. 77, pl. ix, figs. 1–3.
1873. *Pecten deletus* Manzoni, p. 14.
1881. *Pecten deletus* de Gregorio, p. 38.
1894. *Pecten deletus* de Gregorio, p. 26, pl. iv, fig. 91.
1896. *Pecten miocenicus* (pars) Vinassa de Regny, p. 203.
1897. *Aequipecten deletus* Sacco, part 24, p. 19, pl. vi, figs. 1*a*, *b*, 2, 3.
1900. *Chlamys deleta* Rovereto, p. 63, pl. iii, fig. 11*a*.
1911. *Chlamys deleta* Boussac, p. 163, pl. vii, fig. 23.

Locality and Material.—Ramle, one specimen.

Description.—A suborbicular, equivalve, moderately inflated, slightly inequilateral *Chlamys* with about sixteen rounded ribs in each valve, separated by interspaces of about their own width. The ribs of the right valve are slightly more prominent than those of the left. In the right valve both ribs and interspaces are smooth. In the left valve both ribs and interspaces are ornamented with squamose radial threads, but those on the ribs are faint. The auricles in each valve are of moderate size, subequal, and faintly ribbed.

Remarks.—The difference in the sculpture of the two valves is the chief feature which distinguishes typical *C. deleta* from certain Miocene forms (*C. cameretensis* (Fontannes) and *C. praescabriuscula* (Fontannes)), which it closely resembles.

The specimen now described has rather fewer ribs than those figured by Michelotti, Sacco, and Rovereto (in which the number is 18–20). The ribs are relatively wider in the right valve figured by Michelotti, but not in those figured by the other authors cited.

Distribution.—Lower to Upper Oligocene of Venetia. Middle Oligocene of Liguria. Oligocene of San Marino, Sicily, Malta, southern France, and Algeria. Fuchs (1875, p. 99) also records this species from the Aquitanian of Malta, but I doubt his determination, as also that of Miocene specimens from Persia figured by him (1879,

p. 105, pl. ii, fig. 7) as *Pecten* cf. *deletus*. Specimens from the Upper Oligocene of the Trentino figured by Venzo (1933*a*, pl. i, figs. 13, 14) as *Flabellipecten deletus* appear incorrectly determined; the true *Pecten deletus* is not a *Flabellipecten*. The specimen from the "Priabonian" of Cyrenaica recorded by Newton (1911, p. 644) as *Aequipecten* cf. *deletus* has only 9–10 ribs and is probably unrelated.

Chlamys (*Aequipecten*) *deleta* var. *intercosticillatina* Sacco.

Pl. XVII, Figs. 1*a*, *b*.

? 1894. *Pecten deletus* mut. *postprotractum* de Gregorio, p. 26, pl. iv, fig. 94.
1897. *Aequipecten deletus* var. *intercosticillatina* Sacco, part 24, p. 19, pl. vi, fig. 5.
1900. *Chlamys deleta* var. *intercosticillatina* Rovereto, p. 63, pl. iii, fig. 11*b*.
? 1918. *Pecten* (*Aequipecten*) *deletus* Dollfus, p. 92, pl. viii, figs. 8, 9.

Locality and Material.—Ramle, three specimens.

Description and Remarks.—In this variety the left valve resembles that of the type-form of the species. In the right valve the interspaces have squamose radial threads, but the ribs are smooth. The ribs number from sixteen to eighteen in the specimens now recorded.

This appears to be the most abundant variety of the species found at Ramle. The right valve from France figured by Dollfus (loc. cit.) is closely comparable to those from Palestine referred to this variety. According to the description given by Dollfus, however, associated left valves have smooth ribs and interspaces.

Distribution.—Middle Oligocene of Liguria. Oligocene of Venetia? Upper Oligocene of southern France?

Chlamys (*Aequipecten*) *quinquepartita* (Blanckenhorn).

Pl. XVIII, Figs. 2, 3.

1890. *Pecten quinquepartitus* Blanckenhorn, p. 352, pl. xix, figs. 2, 3.
1897. *Aequipecten* ? *oligosquamosus* Sacco, part 24, p. 19, pl. vi, fig. 8.
1900. *Chlamys oligosquamosa* Rovereto, p. 61, pl. iv, fig. 15.
1921. *Chlamys bruzzoi* Stefanini, p. 129, pl. xviii, fig. 2.

Locality and Material.—Ramle, one bivalve specimen and two single valves.

Description.—A suborbicular, equivalve, slightly inequilateral *Chlamys* with sixteen to eighteen rounded ribs in each valve, separated by interspaces of about their own width. The top of each rib bears a series of fairly wide imbricating scales which are evenly spaced except sometimes near the ventral margin, where they may become crowded together and very prominent. The interspaces and sides of the ribs bear squamose threads which vary in number and prominence in different specimens; when least prominent they number up to ten in each interspace, but when most prominent they may number only five or six, of which those on the sides of the ribs are the widest, giving the ribs a tripartite appearance. The auricles are subequal, of moderate size, and ornamented with squamose threads.

Remarks.—Professor Blanckenhorn, who himself (1931, p. 21) recognized this species at Ramle, has very kindly sent me the rubber "squeeze" which served as the original of his figs. 2*a*, *b*; the rest of his type-material is in the Hebrew University, Jerusalem. The sculpture agrees well with that of the specimens from Palestine except that the scales on the crests of the ribs are somewhat narrower; the number of ribs is about the same. The fragment represented in Blanckenhorn's fig. 3 is still more similar to the specimens from Ramle, and I think that there can be no doubt as to the correctness of their reference to this species. As already explained (p. 338), Blanckenhorn's types came from beds of probably Oligocene age near Tab, north of Aintab, in northern Syria.

The specimens from Ramle also agree with Sacco's description and figures of *C. oligosquamosa*, except that they have rather fewer ribs (the number stated by Sacco is 18–20). The specimen with the weakest intercostal sculpture agrees closely with Stefanini's figures of *C. bruzzoi*, from the Oligocene of Cyrenaica, except that that form has rather fewer (only fifteen) ribs. Such slight differences in the number of ribs appear to me to be unimportant, and I have placed both *C. oligosquamosa* and *C. bruzzoi* in the synonymy of *C. quinquepartita*. In *C. gravesi* (d'Archiac) (= *bellicostata* (Wood)), another Oligocene form, the sculpture of the ribs is comparable, but the ribs are appreciably narrower and number twenty-two or more.

Distribution.—Oligocene (?) of Syria. Oligocene of Cyrenaica and Algeria. Middle Oligocene of Liguria.

Chlamys (*Aequipecten*) cf. *perrugosa* (Sacco).
Pl. XVIII, Fig. 4.

The reference to the description of the type-form is :—

1897. *Aequipecten ? oligosquamosus* var. *perrugosa* Sacco, part 24, p. 20, pl. vi, fig. 9.

Locality and Material.—Ramle, one fragment showing the marginal end of two ribs.

Description and Remarks.—The complete specimen must have exceeded 60 mm. in height. The two preserved ribs are broad and rounded, and are separated by narrow but flat interspaces. They bear prominent erect scales, which are about 2 mm. apart except near the margin, where the distance between them diminishes. The edge of each scale is curved round towards the umbo.

The ornament of this fragment appears identical with that of the right valve figured by Sacco. As stated in Sacco's description, the ribs are wider and closer together than in typical *C. oligosquamosa*, and I am doubtful if this form is merely a variety of that species. *Chlamys prenimia* Rovereto (1900, p. 61, pl. iii, fig. 9) seems to be distinct from *C. perrugosa*, although placed in its synonymy by

Sacco (1904, part 30, p. 141); in the right valve the interspaces are as wide as the ribs, while the scales on the ribs are less numerous than in *C. perrugosa.*

Distribution of C. perrugosa.—Middle Oligocene of Liguria.

Chlamys (*Aequipecten*) *judaica* sp. nov.

Pl. II, Figs. 2, 3; Pl. XVIII, Fig. 1.

Locality and Material.—Ramle, three left valves, of which L. 62173 (Pl. XVIII, Fig. 1) is selected as holotype, and one right valve.

Specific Characters.—Shell of medium size, fan-shaped, subequilateral, inequivalve, with both valves ornamented with a rather variable number (nine to eleven or more) of smooth rounded ribs, separated by interspaces of about the same width. Right valve moderately convex, with very prominent ribs; the auricles are missing in the only available specimen, but traces of a ctenolium remain and the byssal sinus appears to have been deep. Left valve feebly convex in its umbonal region, almost flat over the greater part of its surface, with its ribs less prominent than those of the other valve; ribs and interspaces are crossed by excessively fine growth-threads; the hinge-margin is very long, with the auricles correspondingly large and separated by a sinus from the body of the shell; each auricle bears about four radial threads, which may be very faint.

Dimensions of Holotype.—Length 42·6 mm., height 41·0 mm., inflation 0·5 mm.

Remarks.—The holotype, which has only nine ribs, closely resembles small specimens of the left valve of the well-known Miocene species *Nodipecten* [*Macrochlamys*] *holgeri* (Geinitz), both in its ribbing and in its elongate hinge-margin and large auricles. In left valves which have more ribs, however, this resemblance is less pronounced (Pl. XVII, Fig. 3). The right valve (Pl. XVII, Fig. 2), which I assume belongs to the same species, is quite unlike that of *N. holgeri.* "*Peplum*" *oligopercostatum* Sacco (1897, part 24, p. 39, pl. xii, figs. 22, 23), renamed *Chlamys saccoi* by Rovereto (1898, p. 171; 1900, p. 67, pl. iii, fig. 4), has about the same number of ribs and is similarly inequivalve, but its ribs are squamose and its auricles very much smaller than those of the species now described. *C. miocenica* (Michelotti), as figured by Sacco (loc. cit., pl. viii, figs. 43–9), somewhat resembles the new species, but has more ribs and smaller auricles.

Genus SPONDYLUS Linné, 1758.

Spondylus sp.

Locality and Material.—Ramle, several fragments.

Description and Remarks.—In some specimens the ornamentation consists of weak and rather distantly spinose principal ribs, separated by weak and very unequal secondary riblets. In other specimens, which may belong to the other valve of the same species, the interstitial riblets are more rugose or even definitely spinose, while the spines on the main ribs are closer together.

These specimens may belong to the species *S. cisalpinus* Brongniart, but are too fragmentary for determination.

Genus CARDITA Bruguière, 1789.

Cardita arduini Brongniart.

Pl. XVI, Fig. 5.

1823. *Cardita arduini* Brongniart, p. 79, pl. v, fig. 2.
1870. *Cardita arduini* Fuchs, p. 202, pl. xi, fig. 16.
1896. *Cardita hoernesiana* Vinassa de Regny, p. 200, pl. iv, figs. 6*a*–*c*.
1899. *Megacardita arduini* (with vars. *truncata* and *corbuloides*) Sacco, part 27, p. 11, pl. iv, figs. 1–3.
1900. *Cardita arduini* (with vars. *truncata* and *corbuloides*) Rovereto, p. 82, pl. v, figs. 6, 6*a*, *b*.
1900*a*. *Cardita arduini* Oppenheim, p. 271.
1903. *Cardita arduinoi* Oppenheim, p. 179.
1921. *Cardita arduinoi* Stefanini, p. 131.
1928. *Cardita arduini* Vredenburg, p. 438.
1931. *Cardita* n.sp., Blanckenhorn, p. 21.
1933. *Megacardita arduini* Venzo, p. 214.
1933*a*. *Megacardita arduini* (with vars. *curta* and *elongata*) Venzo, p. 197, pl. i, figs. 6, 7.

Locality and Material.—El Qubeibeh, one specimen with its surface details somewhat obliterated (Professor M. Blanckenhorn Coll.).

Description.—A moderately elongate, trapezoidal *Cardita*, obliquely truncated posteriorly and attaining its maximum height towards its posterior end. It measures 27·9 mm. in length, 20·2 mm. in height, and 14·7 mm. in thickness. The umbones are level with the long, straight postero-dorsal margin, and are placed at about the anterior sixth of the length. Each valve has about twelve radial ribs, which are closest together on its anterior region.

This specimen is undoubtedly referable to the well-known species *C. arduini*, and closely resembles one from the Middle Oligocene of Dego, in the Ligurian Apennines, figured by Sacco (loc. cit., pl. iv, fig. 2) as var. *truncata* of that species; the differences from the type-form are too insignificant for the varietal distinction to be worth maintaining.

Distribution.—Lower to Upper Oligocene of Venetia. Middle Oligocene of Liguria. Upper Oligocene of the Trentino. Oligocene of Cyrenaica and India.

Genus LUCINA Bruguière, 1792.

Lucina rollei Michelotti.

1861. *Lucina rollei* Michelotti, p. 69, pl. viii, figs. 3, 4.
1881. *Lucina rollei* de Gregorio, p. 39, pl. ii, fig. 18.
? 1887. *Lucina rollei* Parona, p. 325.
1900. *Lucina rollei* Rovereto, p. 116.
1901. *Dentilucina rollei* Sacco, part 29, p. 82, pl. xviii, figs. 35–7.
1916. *Lucina* (*Dentilucina*) *rollei* Checchia-Rispoli, p. 95, pl. viii, figs. 6, 6*a*.

Locality and Material.—Ramle, one specimen, consisting of the internal and external moulds.

Description and Remarks.—An oblong, rather compressed *Lucina*, about 57 mm. in length and originally about 43 mm. high. The umbones are placed at about the anterior sixth of the length. The sculpture, which is clearly impressed on the external mould, consisted of rather distant, unevenly spaced, concentric lamellae, the spaces between which are almost smooth. This specimen agrees with *L. rollei* in all particulars.

Distribution.—Middle and Upper Oligocene of Liguria. Oligocene of Montese (northern Apennines) and Sicily. Aquitanian of Sardinia (record doubtful).

Genus MERETRIX Lamarck, 1799.

Meretrix ovisimilis (Kranz).

Pl. XVIII, Figs. 6*a*, *b*.

1910. *Cytherea splendida* Mérian var. *ovisimilis* Kranz, p. 224, text-fig. 3.

Locality and Material.—Ramle, one internal cast.

Description and Remarks.—A moderately gibbose, oblong-ovate, very inequilateral form, measuring 41·4 mm. in length, 29·5 mm. in height, and 26·0 mm. in thickness. The umbonal region is inflated, the umbones prosogyrous and placed at about the anterior tenth of the length. A moderately wide, rounded pallial sinus reaches to about two-fifths of the length of the shell from the posterior end.

The outline of this specimen agrees well with Kranz's figures of his var. *ovisimilis* and of the specimen regarded as intermediate between typical "*Cytherea*" *splendida* and the variety. Kranz states that similar variants of *C. splendida* occur in the Bavarian Upper Oligocene, but Paris Basin specimens of this species do not appear ever to acquire such a strongly inequilateral shape. In the absence of specimens referable to typical "*C.*" *splendida* in the small collection from Palestine now described it seems advisable to treat *ovisimilis* as a distinct species. A specimen from the Upper Oligocene of the Trentino comparable in shape has been figured by Venzo (1933*a*, pl. i, figs. 5*a*–*c*) as *Isocardia subtransversa* d'Orb.; its umbones, however, are more strongly prosogyrous than those of the specimen now recorded.

Distribution.—Lower Schio Beds (Upper Oligocene) of Venetia. Upper Oligocene of Bavaria.

Meretrix sp.

Pl. XVIII, Fig. 7.

Locality and Material.—Ramle, one internal cast.

Description and Remarks.—Originally regularly ovate in outline, rather compressed, measuring 22·2 mm. in length, 17·5 mm. in height, and 9·3 mm. in thickness. The umbones, which are level with the gently sloping postero-dorsal margin, are placed at about the anterior quarter of the length. The pallial sinus is narrow and deep, reaching nearly to the middle of the specimen.

This cast is less elongate than *M. splendida* (Mérian) and *M. reussi* (Speyer), which are perhaps the most closely comparable forms described from the Oligocene.

FORAMINIFERA.

Genus *Nummulites* Lamarck, 1801.

Nummulites cf. *vascus* Joly and Leymerie forma A (*boucheri* de la Harpe).

Pl. XVIII, Figs. 8, 9*a*, *b*.

References to the description of the type-form are :—

1879. *Nummulites boucheri* de la Harpe, p. 146, pl. i, figs. iv, 1–10.
1886. *Nummulites boucheri* Uhlig, p. 205, pl. ii, figs. 7, 8, 10.
1908. *Paronea boucheri* Ravagli, pp. 502, 508, fig. 1.
1908. *Nummulina boucheri* (and vars.) Heim, p. 218, pl. vi, figs. 1–20, 24.
1909. *Paronaea vasca* A, Silvestri, p. 622, pl. xxi, figs. 2, 3, 6, 7.

Locality and Material.—Ramle, numerous specimens.

Description.—A small lenticular form with a blunt periphery ; the largest specimen is 3·1 mm. in diameter and 0·9 mm. thick ; a specimen of average size is 2·5 mm. in diameter and 0·8 mm. thick. Equatorial sections reveal a small nucleoconch and rather slowly increasing whorls of which the fourth attains a diameter of 2·2 mm., so that specimens of average size have just over four whorls. The septa number 11–12 in the second whorl, 12–16 in the third, and 16–23 (usually 18) in the fourth ; their spacing is rather uneven. The septa and walls are relatively thick, the thickness of the latter being about one-sixth of the radial width of the cells. The septa are strongly curved or even have a median angular bend ; their inner portion is radial, while their outer portion curves round so as to meet the wall tangentially. Externally the test is smooth and there is no indication of a central boss. The filaments, which are fine and inconspicuous, usually have a slight sigmoidal curve.

Remarks.—*N. boucheri* has long been recognized as the megalospheric form of *N. vascus*. De la Harpe's type-specimens, which came from the Rupelian of Biarritz, were stated to attain a diameter of 3·5 mm., and to have six whorls at a diameter of 3 mm. ; his figures show that the fourth whorl is about 2·0 mm. in diameter and has 20–4 septa. Specimens from the Lower Oligocene of Hungary described by Uhlig are 2·4 mm. in diameter, and consist of four whorls, the second of which has 14 septa, the third 17, and the fourth 22. Specimens from the Oligocene of Venetia described by Ravagli have up to five whorls and attain a diameter of 3·5 mm. ; a specimen figured by him has 22 septa in its fourth whorl, but one figured by him (loc. cit., fig. 2) under the name *N. boucheri* var. *variabilis* Tellini has only 15 septa in its third and fourth whorls. Silvestri's figure shows 20 septa in the fourth whorl. The last-named and other Italian authors have recorded specimens of *N. boucheri* attaining a diameter of 6 mm.

The specimens from Palestine agree well in size and in the number of whorls with the smaller varieties of *N. boucheri*, but have rather fewer septa to the whorl than specimens of that species from most localities. They differ more especially in their strongly curved or subangular septa, which are more similar to those of the species *N. budensis* v. Hantken than to the gently curved ones of typical *N. boucheri*. Their filaments are mostly more curved than those of the specimens of *N. boucheri* illustrated by de la Harpe, but are comparable to those of the series of specimens figured by Heim. The specimens from Palestine are undoubtedly closer to *N. boucheri* than to any other described species, but in view of the slight differences which have been pointed out it seems advisable to qualify their specific determination.

N. vascus and its megalospheric form *boucheri* first appear in the Priabonian and range throughout the Oligocene. They are known from Belgium and northern Germany as well as from numerous localities in southern Europe.

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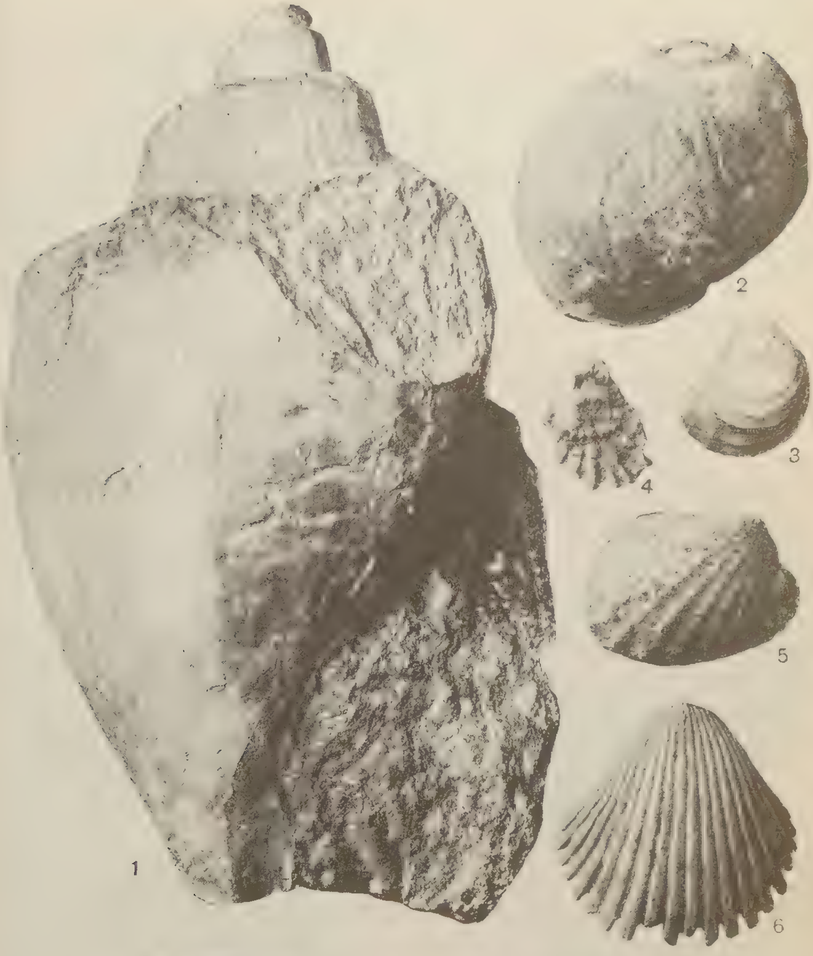

I. R. Cox, photo.

OLIGOCENE FOSSILS FROM PALESTINE.

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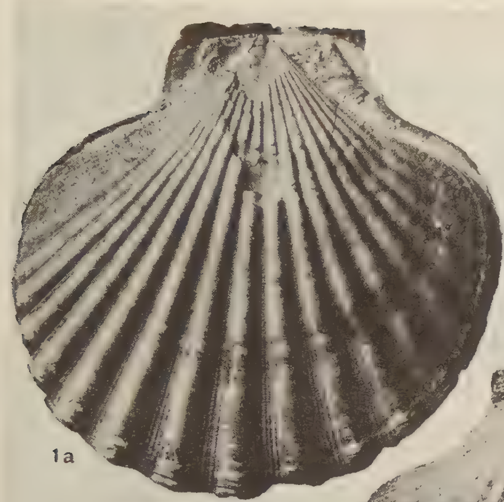

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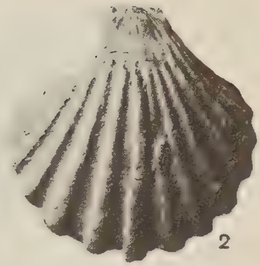

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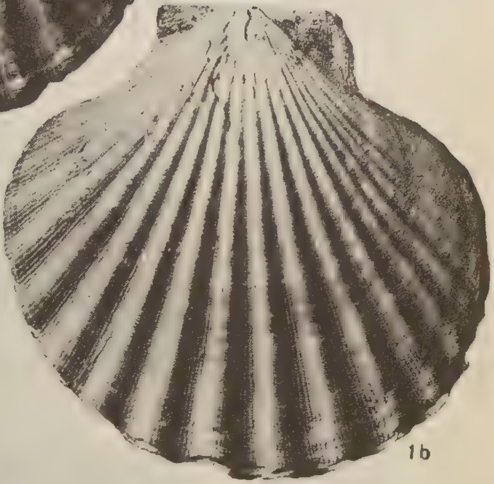

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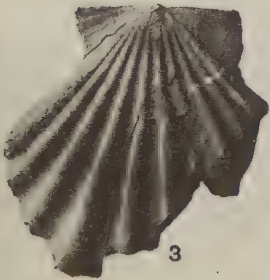

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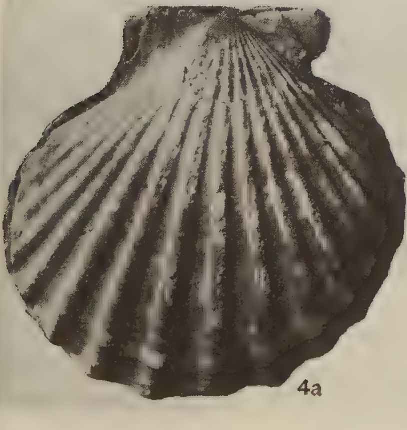

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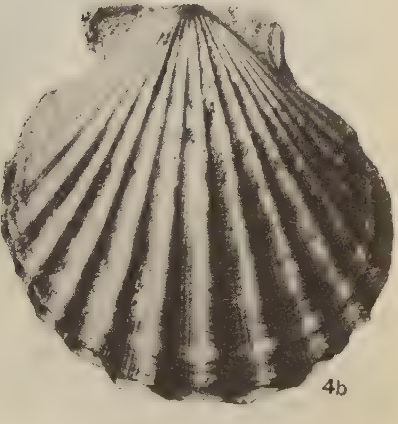

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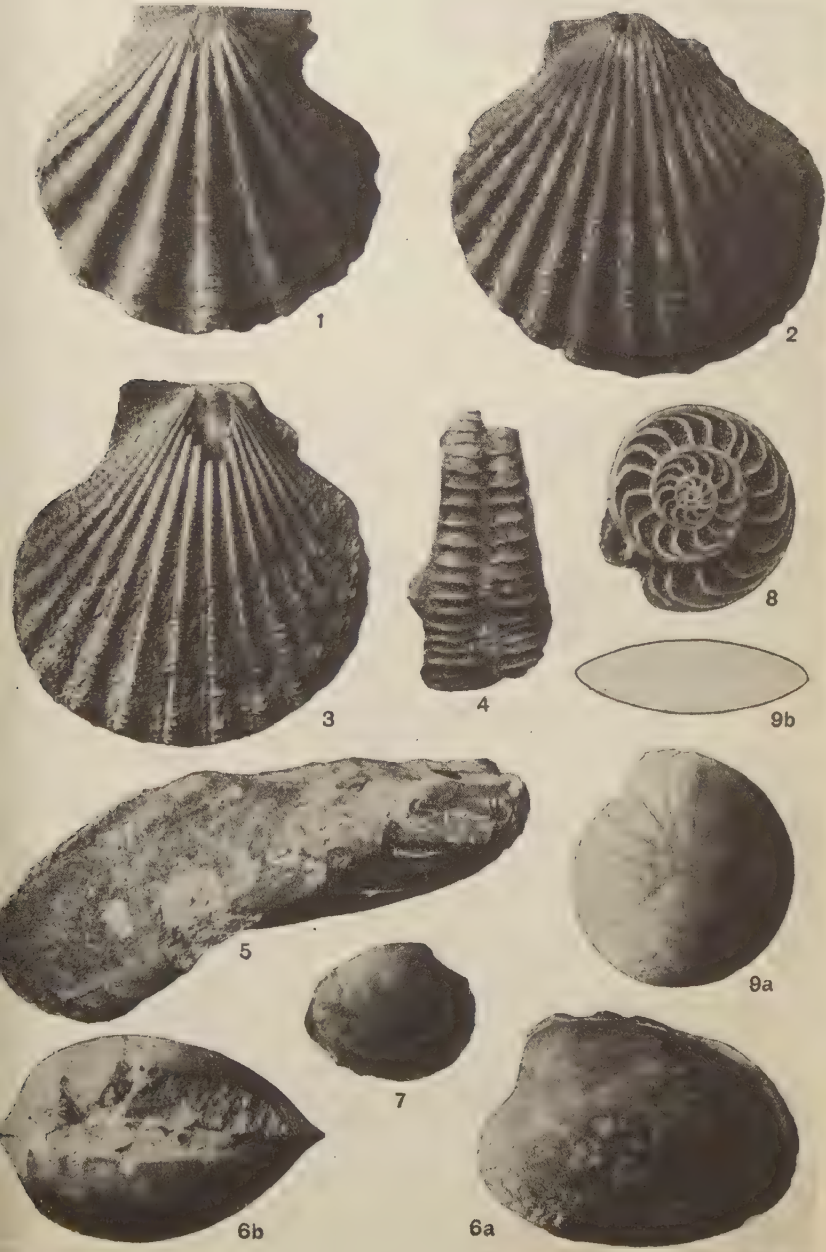
L. R. Cox, photo.

Oligocene Fossils from Palestine.



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EXPLANATION OF PLATES XVI–XVIII.

(All figures are of natural size, unless otherwise stated; figured specimens, except Pl. I, Fig. 5, are in the Department of Geology, British Museum (Natural History), their registration numbers being quoted.)

Plate XVI.

Fig.
1.—*Xancus episomus* (Michelotti), internal cast, G. 56230 (× ½). Ramle. (P. 343.)
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3.—*Ostrea flabellulaeformis* v. Schauroth, right valve, L. 62161. Ramle. (P. 344.)
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7*a*, *b*.—"*Natica*" sp., G. 56224. Ramle. (P. 342.)

Plate XVII.

Fig.
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2.—*Chlamys* (*Aequipecten*) *judaica* sp. nov., right valve, L. 62175. Ramle. (P. 349.)
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4*a*, *b*.—*Chlamys* (*Aequipecten*) *deleta* (Michelotti), forma typica, right and left valves, L. 62167. Ramle. (P. 346.)

Plate XVIII.

Fig.
1.—*Chlamys* (*Aequipecten*) *judaica* sp. nov., holotype, left valve, L. 62173. Ramle. (P. 349.)
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Geology of the Interandine Basin of Cuenca, Ecuador.

By GEORGE SHEPPARD, D.Sc.(Lond.), Ph.D., F.G.S., F.R.G.S.

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I. INTRODUCTION.

THE region which forms the subject of this paper is in the southern part of the Republic of Ecuador (Fig. 1) in the Provinces known as Cañar and Azuay, and is situated between the two principal cordilleras of the Andes at an elevation of about 8,500 feet above sea-level.

Access to Cuenca, the capital of Azuay, can be made either by way of the Gulf of Guayaquil, which necessitates three difficult and arduous days on muleback from the port of Naranjal, or by travelling on the Guayaquil and Quito Railway to Sibambe, from thence to Tambo by railcar, and finally by motor car to Cuenca, via Biblian and Azogues.

During the dry season the latter route is the more advantageous, as it is possible to cover the entire distance between Guayaquil and Cuenca in one day.

A study of the interandine regions forms one of the most fascinating and profitable chapters in the geological history of the Republic. The Cuenca basin is probably the most important of these, as the geology includes a continental facies of Tertiary sedimentation which is almost unique, though similar phases have been recorded from Peru.

II. TOPOGRAPHY AND GEOGRAPHICAL FEATURES.

The Ecuadorian Andes are disposed in two roughly parallel ranges of mountains which pass through the country longitudinally from north to south. Towards the south, however, the parallelism of the respective cordilleras is not well defined, the snow-capped peaks which are so conspicuous in the north do not occur, and the

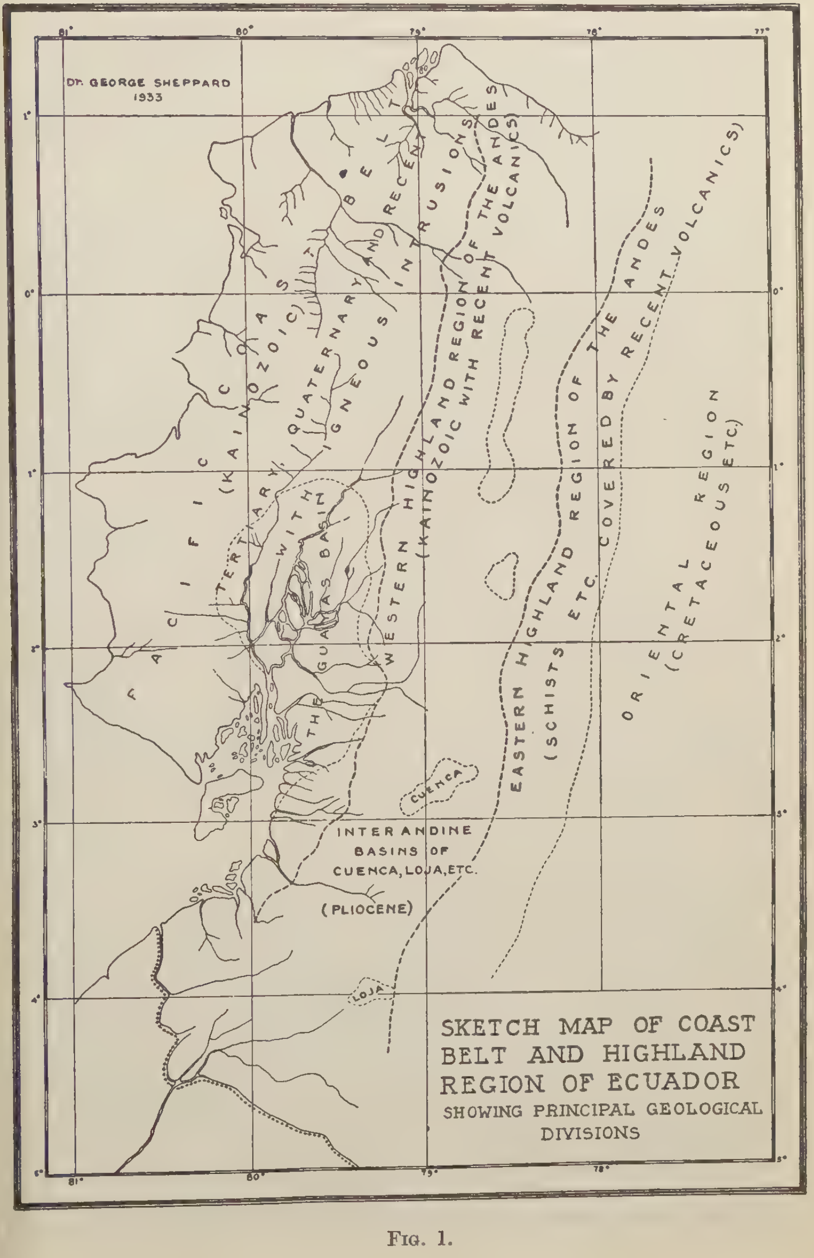
Dr. GEORGE SHEPPARD
1933
81°
80°
79°
78°
77°
1°
0°
1°
2°
3°
4°
5°
PACIFIC COAST (KAINOZOIC) BELT
TERTIARY, QUATERNARY AND RECENT
WITH IGNEOUS INTRUSIONS
THE GUAYAS BASIN
WESTERN HIGHLAND REGION OF THE ANDES
(KAINOZOIC WITH RECENT VOLCANICS)
EASTERN HIGHLAND REGION OF THE ANDES
(SCHISTS ETC. COVERED BY RECENT VOLCANICS)
ORIENTAL REGION
(CRETACEOUS ETC)
CUENCA
LOJA
INTERANDINE
BASINS OF
CUENCA, LOJA, ETC.
(PLIOCENE)
SKETCH MAP OF COAST
BELT AND HIGHLAND
REGION OF ECUADOR
SHOWING PRINCIPAL GEOLOGICAL
DIVISIONS

FIG. 1.

mountains appear to merge into a highly confused geological and topographical complex in the region approaching northern Peru. The well-known volcanoes, active and extinct, which define generally the respective ranges of the Andes, have been described by many observers, including Whymper (1),[1] Reiss and Stübel (2), Meyer (3), Wolf (4), and others, though it should be noted that the topographical distribution and the natural beauty of the high snow-capped peaks have received more attention than has the geology of the formations which underlie them.

So far as is known, the eastern cordillera consists of a vast complex of schists, gneisses, and slates, with intruded igneous rocks and massifs of granite and other plutonic forms. These are flanked on the east by faulted Cretaceous formations (5), which probably extend into the Amazon basin, and may occur beneath the alluvium and silts of that practically unexplored region.

The schists, with their associated igneous intrusions, no doubt underlie the interandine basins, the latter being topographical rather than geological units, though they contain thin deposits of sedimentary rocks of late Tertiary age.

The highest mountains, such as Chimborazo, Cotopaxi, and Tungurahua, are found in the north of the country, and they are doubtless associated with the tectonic lines induced by the two ranges of the Andes. Evidences of vulcanism occur abundantly in the Cuenca basin also, though the respective peaks are rarely high enough to be covered with perpetual snow.

The most important interandine basins of Ecuador are those of Quito, Ambato, Riobamba, Cuenca, and Loja, and although all possess similar topographical characteristics, the Cuenca region is of especial interest by reason of the later Tertiary deposits of continental origin which are found there. This basin is about 30 miles in width, the eastern and western cordilleras being approximately 13,000 feet in height, whilst the lowest part, near Cuenca, is only about 8,500 feet above sea-level.

Most of the rivers of this region flow to the north and north-east, and hence form part of the Amazon system of drainage.

Although remnants of an original peneplain, or mesa, are also found, the topography is extremely varied and confused by reason of the intense subaerial erosion and dissection which has been effected by river action during comparatively recent geological times. Further, we have the important factor of the lithological nature of the formations, and also the presence of volcanic ejectamenta scattered over certain sections, an occurrence which accounts in no small measure for abnormalities in the landscape and unusual features in the topography.

The principal rivers have eroded relatively shallow valleys, though occasionally these are flanked by high and imposing escarpments of sedimentary rock when the river courses, as is usual, follow the strike of the formations. On the other hand, deep gorges are found where igneous dykes or lava flows occur in association with the sedimentary rocks.

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[1] Figures in parentheses relate to List of Works at the end of this article.

The Guayaquil and Quito Railway, at its entrance to the mountains at Bucay, follows the deep gorge of the Rio Chanchan, which has eroded through the recent volcanic rocks such as lavas and extensive deposits of unconsolidated ash and lapillae.

This river, with its tributaries, dissects a relatively flat mesa, or paramo, at an altitude of about 5,000 feet above sea-level. Minor volcanic cones, the chief of which is Cerro Punay, are situated upon this mesa. From Sibambe, the branch line to Tambo ascends the gorge to the top of the mesa, the latter being approached in the vicinity of Tipococha. The whole terrain between Sibambe and Tambo is fundamentally of volcanic origin and consists chiefly of loosely accumulated ash, etc., with occasional lavas and conglomerates. Apart from the deeper river gorges in these soft deposits the paramo country in general has a rolling aspect and is covered by moorland vegetation and low shrubs, with few large trees of any sort. In these higher elevations the climate is too rigorous even for the eucalyptus, and the usual growth consists principally of heather, moss, lichen, and a species of bracken.

The highest part of the paramo is found between Tipococha and Biblian, and this forms a divide about 12,000 feet high between two river systems. Here are also found boulder clays and large striated blocks. The wide valley near Tambo has a distinctly glaciated appearance and in the lower levels are scattered groups of erratic boulders.

Eskers and morainal heaps of the same order occur in the same region, and although but a cursory examination has been made of the deposits, the writer is satisfied that they are glacial in origin, and as such represent some bygone glacial episode in the high Andes of Ecuador.

Further north, in the neighbourhood of Chunchi, the most striking feature in the topography is the mountain known as Santa Rosa, a pyramidal block which has been formed by the erosion of converging river valleys. This mountain consists of volcanic rock, and is probably of the same origin as the hill known as the Devil's Nose, which is seen near the railway to the north of Sibambe. The mesa-like aspect of the country changes, however, at a point about 4 miles north-west of Biblian, where the interandine basin of Cuenca begins, and is approached by the deep and ramifying drainage system of the Rio Biblian. Most of the larger water-courses which traverse the zone between Quito and Cuenca generally flow north and south, e.g. the Rio Guallabamba in the extensive Chillo Valley of the Quito district, the Rio Chambo near Rio Bamba, and the Rios Azogues and Tarqui, which drain the basin of Cuenca. At one time, these streams followed the main structural trends of the geological formations between the east and west cordilleras, as it has been observed, not only in the Cuenca region, but further to the north (6) that the formations, excluding the igneous masses and recent volcanics, strike usually north and south.

The rivers mentioned in the foregoing have thus formed typical strike valleys, having followed the ridges of the more resistant sedimentary and metamorphic rocks, in their initial stages. On the other hand, it must be remembered that important modifications in the topography have been made by the action of recent volcanic disturbances, and these in several cases, have had the effect of ponding pre-existing water-courses and also of initiating new drainage systems.

The surface formations in the vicinity of volcanic cones include ejectamenta, etc., which occur in the nature of colossal screes, deeply channelled. Enormous boulder beds of great thickness and extent also interbed the lavas and ash, and huge fans of this material are found at the outlets of the lateral valleys which, at times, extend far into the respective gorges of the major streams.

Examples have been observed where recent lavas have actually diverted a river, causing the same to follow a completely new course.

III. Geology.

General Succession in the Cuenca District.

(1) Recent Volcanics.
    Loose conglomerates, ash and lapillae, lava flows and ejected blocks, possibly dykes.
(2) Azogues Sandstone (500 ft.).
(3) Cuenca White Shales (200 ft.).
(4) Biblian Sandstones and Conglomerates (? probably very thick).
(5) Volcanic Rocks associated with the above Sedimentaries, e.g. Descanso, Cerro Cojitambo, Cerro Abuga.
    Unconformity.
(6) Schists and Phyllites (Archaean ?).

The Sedimentary Formations.

The Azogues group of sedimentary deposits which include the Azogues Sandstone (4), the Cuenca White Shales, and the Biblian Conglomerates, have been observed for a distance of about 25 miles, viz. from Tambo to Baños (south of Cuenca), and it is possible that the same formations extend east and west as far as the two cordilleras. They are unconformable over the older schists and phyllites (Fig. 2). These formations are especially well developed in the vicinity of Azogues and they are distributed throughout the whole of the Cuenca basin proper. As will be noted below, these sedimentaries are of fresh-water origin, and may have been formed under fluvial or lacustrine conditions. It is not believed that they attain any great thickness. They consist generally of conglomerates, massive sandstones, and thinly laminated silty shales (Fig. 3).

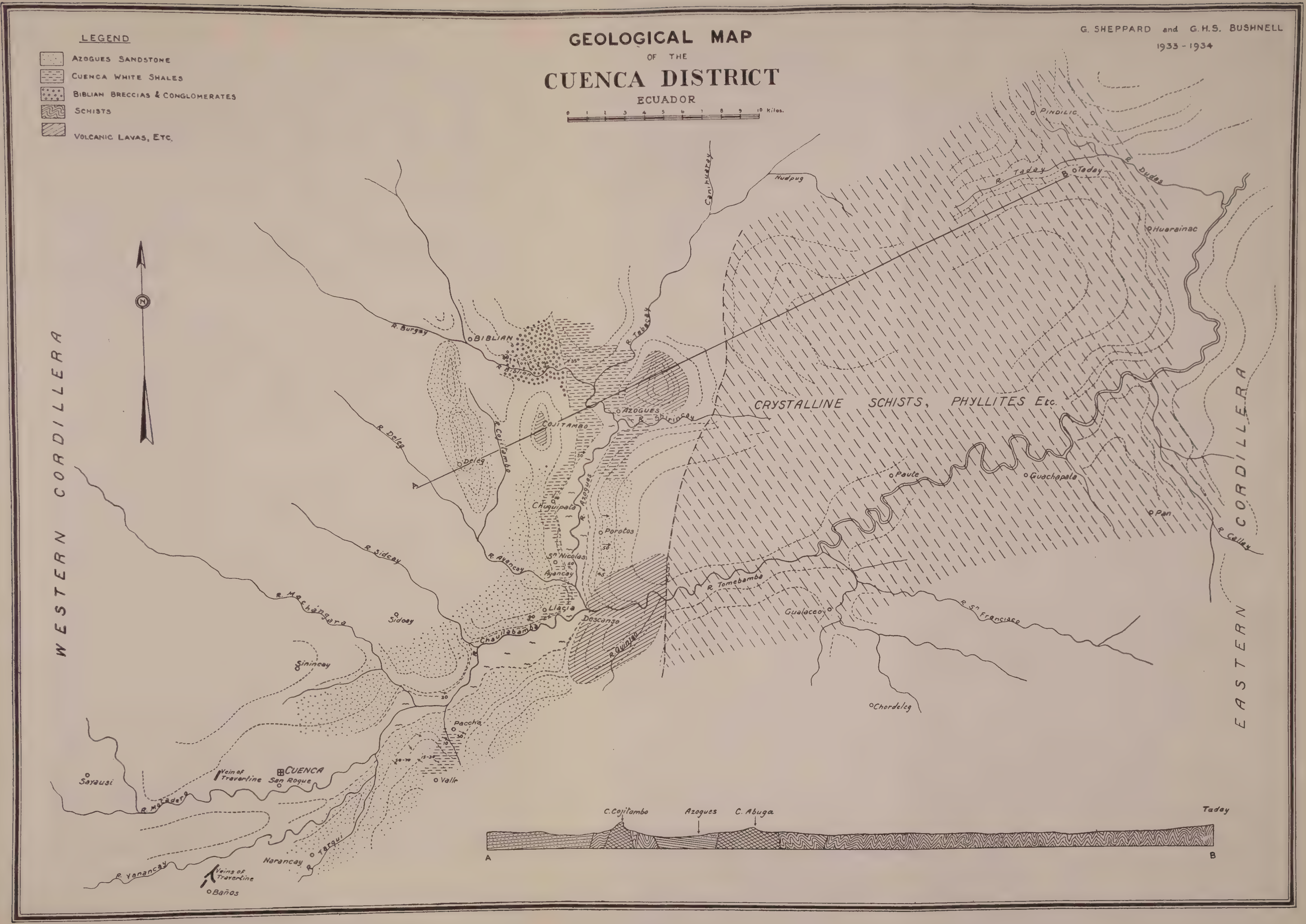

FIG. 2.

[To face p. 360.

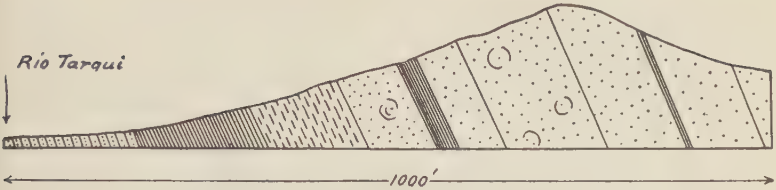

FIG. 3.—Section in Azogues Sandstone and Shales, Valley of the Rio Tarqui, east of Cuenca, Strike N. 15 E.

The shales usually occur towards the base of the section, yet above the conglomerates, and appear to be true lacustrine deposits. Then follow the massive sandstones with occasional pebble seams, the characteristics of which suggest a rapid deposition with strong current action.

The stratigraphical sequence thus indicates a change from lacustrine to river conditions with consequent floods, and an intense denudation of a volcanic terrain. It therefore appears that in its earlier history the Cuenca basin was occupied by a lake in which the finely laminated white shales were laid down. Then, either by a change in the meteorological conditions, or by some similar phenomenon, the lake was replaced by a river system which was responsible for the sedimentation of the sandstones and conglomerates.

(*a*) *The Azogues Sandstone.*

Leopold de Buch, Baron von Humboldt, and T. Wolf have severally described the Azogues Sandstone, the last author summarizing his conclusions in the following words, "Although there can be no doubt as to its Mesozoic age I nevertheless lack geological arguments to justify allocating this sandstone to one of the three great geological formations (viz. the Cretaceous, Jurassic, or Triassic) . . . I have recently noted that Humboldt also (*Kleine Schriften*, p. 131) is inclined to the opinion that the Cuenca Sandstones belong to the Cretaceous formation. These occur geographically between the sedimentary rocks of Colombia and Peru, which formations the earlier authors have considered to be the more ancient rocks (Carboniferous, Permian or Triassic), but which nevertheless by their fossils, collected 1840–1850, have been determined by de Buch as belonging to the Cretaceous. According to these fossils (Buch) it appears proved that all the sedimentary formations of the Andes from Mexico to Cuzco, and lower in the southern hemisphere, belong to the Cretaceous."

Wolf, however, supported by a report of Professor Geinitz on certain fossils found in these same deposits, considered that the Azogues group of sandstones, etc., belonged to the rocks equivalent to the Wealden of Europe, i.e. the oldest section of the Cretaceous (4). In general, the Azogues Sandstone is a pale grey, massive rock, fine to coarse in grain, and not infrequently containing lenticular seams of rolled lava pebbles. The escarpments of this deposit form striking cliffs and weathered sections throughout the region, and are especially well displayed along the valley of the Rio Tarqui. A petrological description of this rock has been already given (7), and it is of importance to note that it consists largely of redistributed volcanic debris, and usually contains fragments of angular lava, altered lime felspars, fresh hornblende, and similar material. It is reasonable to assume, therefore, that this sandstone formation has been derived from the denudation of a volcanic land surface.

In certain localities, near Descanso, fossil wood is abundant, and occurs commonly in the form of logs or driftwood, and thus bears a slight similarity to the estuarine Oligocene beds of Ancon Point, in the southern part of the Province of Guayas.

The most characteristic lithological feature of the Azogues Sandstone, however, is the spheroidal habit which it assumes upon the exposed surfaces. These rounded structures, which range in size from a few inches to several feet in diameter, exhibit exfoliation, a condition which has doubtless been induced by the effects of subtropical weathering. The sediments are, for the most part, non-calcareous, with the exception of the fossiliferous beds which will now be described.

(*b*) *Fossil-bearing Horizons of the Azogues Sandstone.*

Thin calcareous bands of fine sandstone, containing fossils, have been found at Paccha, near Cuenca, and at Biblian. They occur in the lower sections of the series, and have been described by Marshall and Bowles (8).

From a study of these fossils the authors have arrived at the conclusion that they are fresh-water molluscs, and while " at present there are no reliable data to establish the age of the deposits, but as none of the species and none of the genera except *Pomacea* occurs in the recent fauna, it is possible that the age cannot be later than Pliocene, and it may be earlier ".

The collection forwarded by the writer to Dr. Marshall, of the United States Geological Survey, yielded three new genera, each being represented by one new species, and a new species of *Pomacea*. They have been described as *Sheppardiconcha bibliana, Potamolithoides bibliana*, and *Ecuadoria bibliana*.

(*c*) *The Cuenca White Shales.*

The Cuenca White Shales are widely distributed over the present region, type sections of which can be examined along the road near Azogues, and the escarpments near the Rio Tarqui in the vicinity of Descanso. They occur stratigraphically below the Azogues Sandstone, and form part of the same sedimentary group. Lithologically, the deposits are of similar appearance to the marine Eocene shales of the coast-belt (Province of Guayas near Santa Elena). They are light grey, mauve to white in colour, and the weathered outcrops develop exflorescences of sulphur, iron carbonate, and selenite.

Large concretionary masses are also found in the lower sections: they are principally decomposed and iron-stained, and weather out of the shales in defined layers. Smaller nodules, the outer surfaces of which present a cone-in-cone structure, are also a feature of these deposits (Fig. 4).

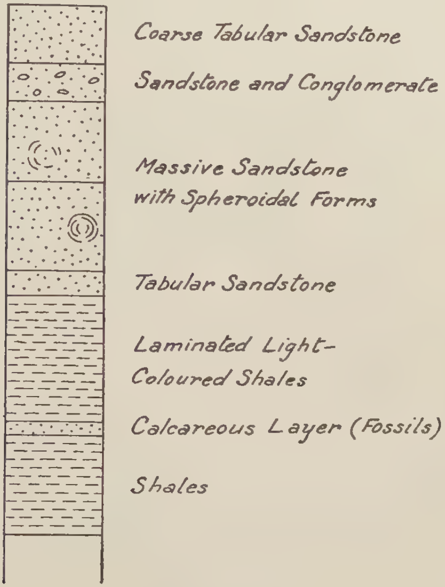
Coarse Tabular Sandstone
Sandstone and Conglomerate
Massive Sandstone with Spheroidal Forms
Tabular Sandstone
Laminated Light-Coloured Shales
Calcareous Layer (Fossils)
Shales

Fig. 4.—Section (500 feet) of Azogues formations near Paccha, Province of Azuay, Ecuador.

The freshly broken shale is dark grey, or bluish in colour, finely laminated, like paper-shales, and occasionally fractures across the bedding in a splintery manner. These strata contain abundant fragmentary lignite remains and fish scales. Veins of selenite are characteristic of the whole series, and in many examples this mineral approaches the form of a fine, white satin-spar or alabaster.

A small seam of brownish lignite, 3 to 4 feet in thickness, occurs in association with the Cuenca White Shales along the valley of the Rio Biblian, about a mile to the north of the town. This working has no commercial value, and probably represents a local development of the lignite or carbonaceous fragments which are disseminated throughout the deposit.

Similar shales to the above have been noted in the Loja basin further to the south (9), (10), and these may form part of the same sedimentary series as the Cuenca White Shales, and are perhaps of the same geological age.

(*d*) *Biblian Sandstones and Conglomerates.*

These deposits form the lowest part of the stratigraphical sequence, and occur along the Cuenca road by the river about 3 miles to the north of Azogues, and in other localities in the basin. On the opposite side of the river the strata are here disposed in the form of a small symmetrical anticline, which has an axial trend north and south, the flanks dipping east and west at about 30°. To the east of this fold, the Cuenca White Shales lie conformably upon the conglomerates of the Biblian group. The latter are well bedded, and are locally massive in habit, varying considerably from grits to conglomerates, the constituent members of which consist of rounded pebbles of lava with occasional dark-coloured quartzites.

Thin silt or mudstone layers are fossiliferous, and thus are similar to the fossil-bearing sandstone of Paccha, near Cuenca. Contemporaneous lavas occur in the Biblian sandstone, being seen in the road sections between Biblian and Azogues. Ash beds and agglomerates are also associated with the lava streams, and the sedimentary rocks on either side are discoloured near the contact.

(*e*) *Veins of Asphalt and Travertine.*

The joints and fissures found in association with the sedimentary rocks already described are occasionally filled by asphaltic material, in veins measuring about 12 inches in thickness, or by travertine which occurs in the form of massive dykes, or walls of crystalline calcium carbonate, these being large enough to form conspicuous ridges in the topography. It is believed that both the above forms of vein deposition have been caused by contemporaneous volcanic action.

The asphalt is a fine, black variety, and is very similar in appearance to the Trinidad asphalt, though it is often hard and brittle with a texture like that of an anthracite.

These asphaltic veins are of sporadic occurrence throughout the region and are always found lining joints or fissures in the Azogues Sandstone.

The travertine deposits of the Cuenca basin are known all over the republic as " marble ". They form an excellent building stone, and many of the larger buildings of the city, including the new university, are made entirely of this material. The travertines are vein deposits, though they occasionally attain a surprising development. They have been caused by the up-welling of heated waters through joints in the sandstone, the deposition of the lime carbonate being relatively rapid. Some of the veins are about 20 feet in thickness and, in certain localities where hot-water springs occur, the ridges have the appearance of high-weathered dykes, some of which are 50 feet or more in height (9).

(*f*) *Geological Structure.*

The geological structure of the late Tertiary formations found in the Cuenca basin is clearly related with the tectonic history of the Andes, and indicates one of the final movements in the orogenic uplift of this important mountain system in Ecuador. From the evidence afforded by the palaeontology, these beds are at least of Pliocene age, and as they are disposed in structural lines which conform with the principal tectonic trends of the cordilleras, they must have been involved in the same crustal movements, and hence the latter can be definitely assigned to an epoch post-Pliocene.

As referred to in the previous discussion the Andes, from Colombia to about Lat. 2° S., consist of two almost parallel ranges which appear to be united in places towards Northern Peru. In the present map area (Fig. 2) the schists, etc., indicated to the east, strike generally north and south, and it is possible that this immense series underlies the whole of the interandine region of Cuenca and Azogues. So far as the newer deposits, viz. the Pliocene beds known as the Azogues Sandstone, etc., are concerned, they are chiefly disposed in sharp folds of a north–south orientation. The anticlinal structure in the sandstones to the south of Biblian is an example of the usual type of folding and, although lavas and possibly dykes have modified the structure locally, they may be of the same or of later age than the initial folding of the sediments. Low dips are rare in the Azogues deposits, and most of the formations are steeply inclined—a structural condition which suggests compression and uplift rather than a dislocation induced by regional foundering. The absence of block-faulting in this area indicates a different type of crustal adjustment from that which is presented by the disturbed beds of the Tertiary coast-belt.

On the other hand, the western cordillera of the Andes consists of stratified formations, Mesozoic, or even Tertiary, with which are associated lavas, dykes, and both granitic and syenitic masses. According to Suess (11) " Towards the sea, the Cordillera Occidental is bordered by a plain, but isolated bosses of syenite and diorite emerge from the limestones of Guayaquil, and, on the east coast of the Island of Puna, Wolf observed a breccia of andesitic lava. The great range of Ecuador consists of a western chain, the continuation of the Cordillera Occidental, formed chiefly of intrusive and effusive rocks of Mesozoic age, and an eastern chain, corresponding to the Cordillera Central, which is composed chiefly of pre-Cambrian rocks ". To the south-west of the Cuenca region the schists and gneisses, with their igneous intrusions, approach the shores of the Gulf of Guayaquil very closely, and have been observed outcropping along a north-easterly line through Pasaje, Santa Rosa, Arenillas. Thus they may form part of a northerly continuation of the Amotape Mountains of Peru, a highly tilted block of geological formations which include " dark slates and quartzites, into which granite has been intruded. In some places they include slates and thin limestone with Palaeozoic fossils. Also in their outer parts there are Cretaceous limestones containing ammonites " (12).

IV. The Igneous Rocks.

The igneous rocks found in the map area consist exclusively of volcanic forms, mostly andesite, and, in certain localities, are associated with schists and other metamorphic rocks. The general section to the south (along the valley of the Rio Paute) has been already described (7), and for the purpose of investigating the northern region the author made a traverse from Cerro Cojitambo, through Azogues, to the old Indian settlements of Taday and Pindilic, and was thus able to complete the mapping as indicated in Fig. 2.

Apart from the igneous outcrop near the entrance to the Paute Gorge, at Descanso, two additional large masses have been examined, these are (*a*) Cerro Cojitambo, and (*b*) Cerro Abuga.

Cerro Cojitambo is a small volcanic cone (Fig. 5), which appears to be of comparatively recent origin, as it breaks through the stratified deposits of late Tertiary age, these having been described in a previous section of this paper. The south-eastern part of the cone has been completely shattered and dispersed, the ejected blocks of lava having been found as far as the village of Chuquipata. These fans of lava blocks are very extensive, and in many instances have become deeply embedded in the softer shales and sandstones of the Azogues group. The sharp peak (nearly 10,000 feet above sea-level) forms a topographical feature of unusual contour, and it is actually a cuspid remnant of the original crater.

(*a*) *Petrological Note on the Cojitambo Lava* (Fig. 6).

The lava is pale grey to mauve in colour, has a rough fracture after the form of coarse limestone or pumice, and contains abundant crystals (dark green and black) of hornblende. Certain varieties of the rock have a tendency to be fissile, especially on the weathered outcrops, this probably having been caused by a secondary foliation associated with the primary flow of the lava.

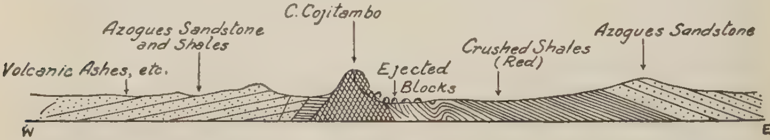

Fig. 5.—General Section (about 3 miles) near Cerro Cojitambo, Ecuador.

Under the microscope the rock is seen to be a typical hornblende-andesite. The felspars, as the hornblende, are of two generations, and are lime varieties of plagioclase of the form labradorite-anorthite. Albite twinning is a constant feature and peripheral zoning is also common. The felspars are usually fresh, though some of the larger phenocrysts are turbid, while several are decomposed and are partially resorbed into the ground-mass. The smaller felspars are fresh and rectangular in contour.

The ground-mass proper consists of a felted complex of minute felspar laths. The hornblende, when fresh, is of a bright green colour, showing typical cleavage with strong pleochroism. This mineral is distinctly of two generations, though the larger elongated sections are less decomposed than the smaller ones. The latter are often considerably altered, and appear as serpentinized decomposition products with a high proportion of magnetite and other ferrous minerals. In most examples, however, the original form of the hornblende crystal can be recognized, though it is usually bordered by specks of opaque mineral products. Fine transparent crystals of apatite are also present. Magnetite occurs sparingly as an accessory mineral, and is seen as minute opaque black specks.

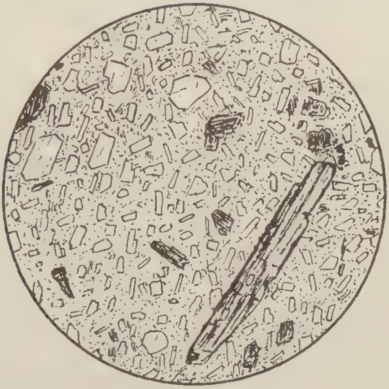

Fig. 6.—Hornblende-andesite (× 25), Cerro Cojitambo, Ecuador.

(*b*) *Petrological Note on the Abuga Lava* (Fig. 7).

By reference to the map (Fig. 2) it will be observed that Cerro Abuga is a high conical hill, which is slightly to the north-east of the town of Azogues. It is in contact with the schists to the east, and with the Azogues sedimentary series to the west. The junction between the latter and the volcanic rock of Abuga is obscure, though it is believed that the intrusion is of later date, and probably forms part of the same igneous phase as that of Cerro Cojitambo, the two types being similar.

A pronounced fissility, caused by foliation, is characteristic of the Abuga lava, and for this reason it is largely employed in the district as a building-stone, especially for paving and even for roofing tiles, as the material splits easily into slabs an inch or so in thickness. The type rock is light grey to cream in colour, and the weathered outcrops are very similar in appearance to a white, sedimentary "freestone", the foliation also giving the general impression of stratification.

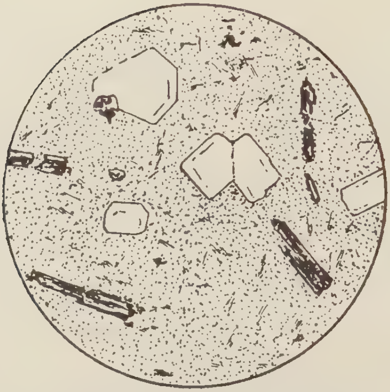

Fig. 7.—Hornblende-andesite (× 25), Cerro Abuga, Ecuador.

Under the microscope the rock is seen to be a hornblende-andesite, differing from the Cojitambo type by the more finely felsitic nature of the ground-mass. It is porphyritic in habit, the larger plagioclase felspars (labradorite-anorthite) being fresh and well formed, and exhibiting both albite and zonary banding under crossed nicols. Green hornblende is an important essential mineral of this lava, and is a fresh constituent. Minute needles of apatite and specks of magnetite are also present in minor proportion. The ground-mass is finely crystalline, and consists principally of a plexus of felspars with magnetite, and can only be resolved under the high power. From the comparative petrology and from their field relations, it is evident that both the Cojitambo and Abuga andesites form part of the same igneous episode, and are possibly both post-Tertiary in age. Thin lava flows have been observed in association with the sedimentary deposits near Biblian; their occurrence being marked by a discoloration of the surrounding rock, and by the presence of brecciated or tuffaceous material.

V. The Metamorphic Rocks.

The geological formations found in the eastern part of the map region consist of metamorphic rocks with intruded dykes. They are all highly inclined and crushed, though it is significant that they have a tectonic trend generally north and south, with corresponding steep dips usually to the west, and occasionally to the east.

The southern section, viz. from Descanso to El Pan, has been described in a previous paper (7), and although no microscope slides have been made from the micaceous slates and schists collected from the present region, there is little doubt that they form part of the same series as the above. How far this series of schists and slates extend to the east is not known, though farther to the north, i.e. east of Ambato and Baños, granites are found in association with the schists and gneisses and, according to Wasson and Sinclair (5), granites and rhyolites occur above Mera.

Between the andesite outcrop of Cerro Abuga and the schists proper, a zone of reddish schistose formations is found which is extensively altered and disturbed. This may be the marginal portion of the schists dislocated and further metamorphosed by the extrusion of the andesite, or may represent a tectonic failure in the crustal formations which preceded the volcanic eruption.

Wolf (4) expressed the opinion that the schists, slates, and gneisses of the eastern cordillera are Archaean in age. This may indeed be the case, but the evidence is based purely upon the lithological resemblances which exist between these rocks and the known Archaean formations of Europe and elsewhere.

VI. CONCLUSIONS.

The Cuenca basin is one of a series of topographical depressions which exists between the east and west cordilleras of the Ecuadorian Andes. Like the Loja district further south, the Cuenca region contains fresh-water sandstones and shales which, by their fauna, date as late Tertiary, possibly Pliocene or even earlier.

From the structural disposition of these newer sediments, which conform with the general orientation of the Andean ranges, it is inferred that they were involved in the same tectonic movements as the compression and uplift of the Andes; and further, that the geological age of the latter must be at least post-Pliocene.

It is also conceivable that at the time of the deposition of the Azogues group of sedimentaries, the Andes had not attained their maximum development as a major mountain range. The width of the Cuenca zone of deposition must have been greater in late Tertiary times than at present, as the sediments of this period are now compressed and steeply inclined, and occasionally folded into sharp anticlines. There are also volcanic manifestations which most probably took place after the folding of the Azogues sediments, and may even be a result of the same tectonic expression.

The exceptionally large veins or walls of travertine found in association with the Azogues Sandstone (Fig. 2), represent structural failures through which heated waters have escaped since the folding took place. In certain places, e.g. at Baños (south-west of Cuenca) these waters are still flowing out of one of the principal vein fissures, and are rapidly depositing calcium carbonate from solution.

A series of major geotectonic movements, or crustal thrusts, most probably operated from the west and south-west in this continental region and took place in post-Tertiary time.

The resulting crustal adjustments were thus expressed in the structure of the sedimentary beds of the interandine basins and also in the Tertiary rocks of the coast-belt..

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Post-Glacial Fossil Mollusca in Western Canada.

By Alan Mozley, the University, Edinburgh, and the Johns Hopkins University.

FROM the standpoint of biological geography, the most significant event in the recent history of Canada has been the occurrence of widespread severe glaciation. This resulted in the whole of the previously existing fauna being either exterminated or driven southward. When the ice sheets receded northwards at the end of the last glacial period, this region was once more populated by animals, including both fresh water and terrestrial mollusca, the remains of which are to be found in various post-glacial deposits. The migration of animals into this new territory did not take place all at once, and it is noteworthy that no fossil mollusca have been found in the deposits laid down during the early stages of the glacial retreat. The purpose of this paper is to give in concise form the history of the present molluscan fauna of this region in so far as it is evidenced by the post-glacial fossils found in the region. The series of fossil-bearing deposits herein described is far from complete, and many additional finds will doubtless be made in the course of future field work. Nevertheless, a sufficient number of observations has been made to indicate the general nature and duration of the molluscan immigration into the area.

Extent of Glaciation in North-Western North America.

Practically the whole of the North American continent lying to the north of north latitude 49°, and to the east of the Rocky Mountains has been subject to very severe glaciation within relatively recent times. With the exception of Alaska, that part of the Yukon Territory lying to the west of longitude 136° 15′ west of Greenwich, and certain restricted areas in Labrador and elsewhere, glaciation was complete. At a period estimated to have been from ten thousand to fifty thousand years ago, the whole of this part of North America was covered by glaciers, which have been estimated by Upham (13, p. 133)[1] to have been up to 2 miles in thickness. Under these conditions the pre-glacial fauna of the region was undoubtedly exterminated or else driven southward. It has been suggested that there may have been islands in the glaciated area which served as refuges for the animals of the region. For example, the western part of the Cypress Hills, near the boundary between the provinces of Saskatchewan and Alberta, and also the Hand Hills in the eastern part of the latter province, appears to have projected above the ice sheet. It is unlikely, however, that conditions of temperature and precipitation capable of producing glaciers 4,000,000 square miles in extent and of great thickness would be suitable for the maintenance of a diversified fauna on such restricted islands as these, and it is therefore improbable that they played any important part in the repopulation of the area, especially in regard to aquatic animals. Therefore, for practical purposes in this connection, glaciation and the attendant extermination of the pre-glacial fauna may be considered to have been complete within the area mentioned.

Repopulation of the Glaciated Area.

At the end of the last glacial period, when the ice sheets melted, a great deal of water was ponded between the southern edge of the glaciers and the height of land near the forth-ninth parallel. Thus in what is now the Province of Manitoba an immense glacial lake was formed. This has been named Lake Agassiz. At one time it had an area of 80,000 square miles, and a depth of 550 feet. As the present (and pre-glacial) outlets into the Arctic Ocean were then blocked by the ice sheet, the drainage of Lake Agassiz was to the south into the Mississippi River, and it was from this source that the elements of the present aquatic fauna of this region were derived.

Subsequent further retreat of the ice northward opened a channel into the Arctic Ocean, and the drainage was diverted from the Mississippi to the north-east, and the height of land near north latitude 49° became the divide between the watersheds of the Hudson Bay and Mississippi drainage systems. After a further slight advance the ice sheet retreated northwards and Lake Agassiz was rapidly drained. The aquatic animals which had migrated into this area from the south were then trapped in the northern drainage system and lost all possibility of any genetic admixture with the southern fauna. To this separation is probably due, at least in part, the continuance of the faunistic peculiarities of this northern drainage.

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[1] Numbers and page references refer to the Bibliography given at the end of this paper.

The greater part of Alaska, and that sector of the Yukon Territory which lies west of meridan 136° 15′ were not covered by the continental ice sheet and it might be suggested that this area served as a reservoir from which molluscs and other animals migrated after the retreat of the glaciers. As far as the mollusca are concerned, this is extremely unlikely, since even at the present time the climate, physiography, and drainage of the area are not such as to encourage the migration of molluscs between the two areas, and there is no reason for believing that at any previous post-glacial period these conditions have been more favourable than is the case at present.

In view of the very similar constitution of the molluscan fauna of the western part of Canada east of the Rocky Mountains and that of the Mississippi drainage system, it is certain that they must have been derived the one from the other, or from some common source. The former existence of a direct drainage connection between these two areas is a sufficient explanation, and there is little doubt that the western part of Canada east of the Rocky Mountains received the elements of its aquatic fauna from the south.

From this account it will be obvious that definite information regarding post-glacial fossil molluscs in this region is a desideratum, and it is the purpose of this note to present certain original observations regarding them, as well as references to other records in the literature. An account of the constitution and local distribution of the living mollusc fauna of this region at the present time will be given in a later paper. It need not be assumed on the basis of the point of view here expressed that the development of this northern fauna has been a simple and straightforward process. In fact, though it may not always appear so, the study of this fauna in Canada is complex to a high degree, and the work will not be completed for several years.

Types of Deposits containing Fossil Molluscs.

Post-glacial fossil mollusca are to be found in a variety of different deposits in this region, some of which have been laid down in large glacial lakes, others by streams, or by smaller non-glacial lakes. The lacustrine deposits are characterized by a fauna consisting mainly of pelecypods such as *Lampsilis*, *Anodonta*, and *Sphaerium*, together with certain gastropods such as *Amnicola* and *Valvata*. A very similar fauna is to be found living at the present time in Lakes Winnipeg, Winnipegosis, and Manitoba, which are the successors of the glacial Lake Agassiz.

The stream deposits have a fauna which as a rule includes both gastropods and pelecypods, but the species represented in any one bed vary widely according to the nature of the stream by which they were deposited. Birdtail Creek has laid down deposits of gravel near Birtle, Manitoba, which contain eight different species of Unionidae, while many of the delta silts contain little or none of this pelecypod material.

The fossil fauna of the deltas of streams emptying into the immediate successors of glacial Lake Agassiz, as well as those laid down in more recent times, taken as a whole, is highly characteristic and it may therefore be worth while to discuss it in greater detail.

It is well known that many species of mollusca are quite specific in their habitat requirements, some being found only in one type of habitat and some only in others. The most characteristic feature of the fossil fauna of delta deposits in this region is the association in the one bed of the shells of molluscan species from many diverse types of habitat. The fossil fauna of the delta deposits indicates that a good deal of admixture has taken place during deposition. On its way down from the headwaters a stream gathers a large number of living molluscs and empty shells, terrestrial species which are washed into the stream in times of flood, and aquatic species, not only the normal inhabitants of streams, and also shells carried away from their usual habitats in ponds or marshes. These are carried downstream by the current, fall to the bottom near the mouth of the stream, and there build up characteristic deposits.

A good example of a deposit having this origin and type of fauna is found in the vicinity of the Pasquaia River about 1 mile to the west of the town of Le Pas, Manitoba. The Pasquaia River rises in the hills of the same name situated about sixty miles to the south-east of Le Pas. In the neighbourhood of this town it has cut a channel, about ten feet in depth, through beds of fine silt so that a moderately good vertical section is exposed in places along its banks. For several miles to the south-west of this point the country is mainly of a flat marshy nature and is subject to periodical flooding. It is from these floods that the silt has originated. Fifteen species of molluscs are found fossil in this deposit, and since all of them are forms which are now living in the western part of Canada, it has been possible to trace the derivation of the fossil fauna with a good deal of accuracy.

HABITAT PREFERENCES OF THE MOLLUSCS FOUND AS FOSSILS NEAR LE PAS, MANITOBA.

TERRESTRIAL SPECIES.	HABITAT.
Retinella hammonis (Strom.)	In moist woods.
Zonitoides nitida Müller	In moist woods.
Gonyodiscus cronkhitei anthonyi (Pilsbry).	In moist woods.
Succinea ovalis Say	In moist woods, never along the banks of streams or in marshes.
Succinea avara Say	Among vegetation in moist or wet localities, commonly on the banks of streams and in marshes.

AQUATIC SPECIES.	
Limnaea stagnalis jugularis (Say).	The more stagnant places in permanent ponds, lakes, and rivers. Never in temporary ponds.
Limnaea vahlii (Möller) .	Ponds and marshy areas containing water permanently, or only for a part of each year, i.e. in temporary ponds and intermittent streams.
Limnaea caperata Say . .	Very similar to *L. vahlii*, particularly in temporary ponds.
Limnaea sp. (distinct from *L. vahlii* ?)	
Planorbis trivolvis Say . .	Quiet water in permanent ponds, lakes, and marshes.
Planorbis sp. (distinct from the above).	
Planorbula campestris Dawson	Temporary ponds, situations which are dry during a part of each year. Never found elsewhere.
Planorbula sp. (distinct from the above ?)	
Physa gyrina Say . .	Ponds, lakes, and streams.
Aplexa hypnorum (Linné) .	Temporary and permanent (?) ponds, small streams.
Valvata lewisi Currier . .	Small lakes, sometimes in the more open marshes.
Musculium sp.	

The habitat preferences or requirements of the various species which are shown in the accompanying table indicate clearly the variety of the sources of the fossil fauna of this deposit. Some of the species represented are terrestrial, and others are aquatic. Several of the land snails live in the neighbourhood of streams and marshes, while others are seldom or never found in such situations and occur only in moist forests away from streams and marshes. Similarly, in the case of the aquatic species some are characteristic of ponds which are dry during a part of each year, while others are intolerant of such conditions and are to be found only in permanent waters. With one exception typically lacustrine species are absent from this deposit.

Continuity of the Series.

In spite of the obvious gaps in the series, a fair degree of continuity has been established in the course of this work between the mollusc fauna existing in western Canada in early post-glacial times and that found living in the region at present. Early Lake Agassiz, according to present evidence, contained no molluscan life. Later, but while it was still a true glacial lake, with an outlet to the south, it is shown to have contained, at least in some places, a fauna comparable in abundance and variety to that of the larger lakes in this region at the present time. Apart from the desirability of placing on record the specific observations, the object of this paper is to indicate the essential unity of the immediate post-glacial fauna with that of the present time and to emphasize the very recent emergence of this fauna as a separate unit in the fauna of the Sub-Arctic region.

1. LAVENHAM, Manitoba.

Approximately 3 miles to the south of the village of Lavenham, and 8 miles north of Treherne, Manitoba, not far from the Assiniboine River, there is a moderately good section of one of the Agassiz beaches. Fifteen or more species of fresh-water molluscs are represented in this deposit, all of which are lacustrine forms.

It is not clear which of the beaches of Lake Agassiz is represented here, but it appears that it is almost certainly older than the Campbell Beaches, and is probably not far below the Upper Tintah or Norcross Beaches.[1] The elevation of this deposit is approximately 1,160 feet. The species found in this deposit are as follows :—

Limnaea obrussa decampi (Streng)
Limnaea sp.
Planorbis antrosus Conrad
Planorbis arcticus (" Beck " Möller)
Valvata tricarinata (Say)
Amnicola walkeri Pilsbry
Amnicola limosa porata (Say)
Amnicola sp.
Lampsilis [2] *siliquoidea rosacea* (De Kay)
Anodonta sp.
Sphaerium simile (Say)
Sphaerium sp.
Pisidium spp.

2. CAMPBELL, Minnesota (Upham, 13, p. 237).

" *Unio ellipsis* " is reported from the Campbell Beach 6 miles south-west of Campbell, Minnesota, at an elevation of 985 feet.

3. GLADSTONE, Manitoba. (Upham, 13, p. 237).

Gladstone Beach of Lake Agassiz one-half mile north-east of Gladstone, Manitoba. Altitude, 875 feet.

Lampsilis siliquoidea Barnes
Sphaerium striatinum Lamarck
Sphaerium simile Say
Planorbis parvus Say

4. HAUTE, Manitoba. (Mile 93, G.W.W.D.Ry., Johnston 5, p. 32.)

Johnston found the remains of four species of molluscs in Agassiz clays at this locality near Shoal Lake, one of the waters connected with the Lake of the Woods.

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[1] Mr. W. A. Johnston of the Canadian Geological Survey, agrees with me that this beach stands higher than the Campbell Beaches.

[2] Fragments of a third member of the family Unionidae were found but not identified.

Lampsilis siliquoidea Barnes
Strophitus rugosus Swainson
Sphaerium rhomboideum Say
Sphaerium stamineum Conrad

5. Fort Francis, Ontario. (Coleman, 5, p. 147.)

In addition to the bones of a small fish, and a bony plate of a sturgeon, the following species were found in Agassiz clay in this vicinity :—

Limnaea stagnalis ?
Limnaea desidiosa
Limnaea palustris
Planorbis antrosus
Planorbis deflectus
Valvata sincera
Valvata bicarinata ?
Valvata tricarinata
Amnicola limosa
Pleurocera sp. ?
Lampsilis recta
Sphaerium sp. ?
Pisidium spp.

6. Pine River, Ontario. (Lawson, 8, pp. 172 f.)

Along the Rainy River in fresh-water beds, which are probably of Agassiz age, Lawson found the bones of Buffalo (*Bos americanus* Gmelin) and shells of the following species :—

Limnaea desidiosa ?
Planorbis antrosus
Sphaerium simile
Sphaerium striatinum

7. Fort Garry, Manitoba. (Mozley, 10, pp. 267–270.)

A deposit containing twenty-three species of fresh-water and terrestrial molluscs was found on the west bank of the Red River, three miles (in a direct line) to the south of its junction with the Assiniboine River, a short distance south of the city of Winnipeg.

The material as exposed is a silty clay ranging from a light to a dark grey in colour, and varying considerably in composition. Extremely thin layers of a light grey clay are sometimes found interleaved with a coarse silt. The western bank of the Red River at this point is being eroded at a fairly rapid rate, and as a result a good section, some twenty-five feet from low-water level to the top of the bank is exposed. This section exhibits rough horizontal stratification, and cross-bedding was noted at one point. At a depth of eight feet below the top of the bank a thin but clearly marked and continuous stratum of charcoal is found, which probably represents the drift from an old forest fire. The beds are Post Glacial in age and have evidently been laid down in delta flood plains. It is probable that they were deposited by one of the rivers running into the lakes formed during the period of the drainage of Lake Agassiz, and after the waters of this drainage had acquired their fauna from the Mississippi. The following species were found here :—

Vallonia costata Müller
Vallonia parvula Sterki

Retinella hammonis Strom.
Gonyodiscus cronkhitei anthonyi Pilsbry
Succinea ovalis Say
Succinea sp.
Limnaea obrussa exigua Lea
Limnaea arctica Lea
Limnaea caperata Say ?
Planorbis parvus Say
Planorbis sp.
Planorbula crassilabris (Walker)
Aplexa hypnorum Linné
Physa integra Haldeman
Amnicola limosa Say
Amnicola emarginata (Küster)
Amnicola winkleyi mozleyi Walker
Valvata tricarinata Say
Ferrissia rivularis Say

Sphaerium striatinum Lamarck
Sphaerium solidulum Prime
Sphaerium stamineum Conrad
Sphaerium acuminatum Prime
Sphaerium notatum Sterki
Sphaerium emarginatum Prime
Sphaerium torsum Sterki
Pisidium fallax Sterki
Pisidium compressum Prime
Musculium transversum Prime

8. Elm Park, Manitoba.

The eastern bank of the Red River in the Municipality of Saint Vital at a point approximately half a mile to the south of the limits of the city of Winnipeg has been considerably eroded during the spring floods when great masses of ice are carried down the river. As a result there is a good exposure in section of the silty material of which the banks are built. The silt is very similar to that found in the Fort Garry deposit (No. 7) which is only about two miles distant. Quite apart from their being close together and at approximately the same elevation, the resemblance of the fossil faunas and the similarity of the material in which these are found indicates that these two deposits are probably contemporaneous, if not actually part of the same deposit. The only visible difference in the material in these two deposits is the rather less well defined horizontal stratification at Elm Park.

The molluscs found as fossils in this locality include eleven species as noted below. It may be worthy of mention that this is the third locality from which *Amnicola winkleyi mozleyi* Walker has been reported.

Limnaea sp.
Planorbis sp.
Physa sp.
Ferrissia sp.
Valvata tricarinata Say
Amnicola emarginata Küster
Amnicola winkleyi mozleyi Walker
Sphaerium spp.
Musculium sp.
Succinea ovalis Say
Gonyodiscus cronkhitei anthonyi Pilsbry

9. Saint Vital, Manitoba.

Along the eastern bank of the Red River one and a half miles above the Fort Garry deposit (No. 7) noted above, a few fresh-water shells are to be found. The material in which they are embedded and their situation is similar to that in deposits Nos. 7 and 8. The following two species have been found at this point :—

Limnaea sp.
Amnicola emarginata Küster

10. LAVENHAM, Manitoba.

Several miles to the south of Lavenham station (C.N.R.) and one-quarter mile west of the Agassiz deposits in that vicinity already described (No. 1) there is a bed of sand which contains at least eight species of fresh-water molluscs. This appears to be very much younger than the first Lavenham deposit (No. 1) but is possibly of greater age than the third deposit in this neighbourhood (No. 17). This sand bed is on the eastern bank of the Assiniboine River and is a very much localized belt, being approximately ten feet in height and twenty-five feet in length. It is quite a distinct deposit from the old Agassiz beach (No. 1) which, while not far away, is fully sixty feet above it. The molluscs found as fossils in this deposit were the following :—

Planorbis sp. (somewhat resembling *P. parvus*)
Planorbis sp., fragment distinct from above ?
Planorbula crassilabris Walter
Planorbis antrosus
Valvata tricarinata (Say)
Valvata lewisi Currier ?
Sphaerium sp.
Pisidium spp.

11. BIRTLE, Manitoba.

Along the banks of the Birdtail Creek about two miles to the north-east of the town of Birtle, Manitoba, is a bed of gravel lying eight feet above the present (low-water) level of the stream. This deposit contains eight species of Unionidae in some abundance. Although the Birdtail Creek has been examined for living forms with considerable care on two occasions, there are twice as many species to be found fossil as appear to be living in this section of the stream at the present time. In the following list of species found fossil in the gravel bed, those forms which are also found living in the stream at the present time are marked with an asterisk.

*_Lasmigona complanata_ Barnes
Lasmigona compressa (Lea)
*_Lampsilis siliquoidea rosacea_ De Kay
Lampsilis ovata canadensis (Lea)
*_Strophitus rugosus_ (Swainson)
*_Anodonta grandis footiana_ Lea
Fusconaia flava (Rafinesque)
Eurynia recta (Lamarck)

12. DAUPHIN, Manitoba.

The Vermilion River near Dauphin is a very small stream but has cut a good section through the silt lying to the north-east of the bridge of the Canadian National Railways. The material in which the shells are to be found is a silty clay of a grey-brown colour. The following species have been found here :—

Limnaea sp.	*Valvata tricarinata* (Say)
Planorbis sp. (like *parvus* Say)	*Sphaerium* spp.

13. Deer Lodge, Manitoba.

Along the northern bank of the Assiniboine River one-half mile to the east of Deer Lodge, a section of the delta silts about ten feet in thickness is exposed. An examination of the fauna of this deposit has been made with some care on two occasions and the collections obtained are remarkable for the great preponderance of terrestrial species in the fossil fauna. Of the six species which have been found on this site five are land forms. In point of individuals in the collections the terrestrial species far outnumber the aquatic forms. In this respect the Deer Lodge deposit stands in striking contrast to other fossil-bearing post-glacial deposits in this general neighbourhood (e.g. Nos. 7, 8, 9, and 14). The species found at Deer Lodge are listed below.

Terrestrial species.

Gonyodiscus cronkhitei anthonyi (Pilsbry)
Retinella hammonis (Strom.)
Vallonia sp.
Cochlicopa lubrica (Müller)
Carychium sp.

Aquatic species.

Planorbula crassilabris (Walker)

14. Saint Charles, Manitoba.

In silty material exposed on the southern bank of the Assiniboine River near the Saint Charles ferry directly to the south of the village of that name the shells of one species of fresh-water mollusc are to be found, namely :—

Sphaerium sp.

15. Morris, Manitoba.

At least two species of mollusca are to be found in silt laid down on the flood plain of the Red River near Morris, and to be found exposed on the eastern bank of that stream two miles above the village. These are as follows :—

Planorbis sp.
Sphaerium spp.

16. Portage la Prairie, Manitoba.

Deposits of silt and sand exposed in section on the north bank of the Assiniboine River approximately two miles to the south-east of the Portage la Prairie railway station, and one-quarter mile east of the water tower of the town, have yielded a relatively large number of fossil, fresh-water, and terrestrial mollusca.

Aquatic species.

Limnaea sp. (broken)
Planorbis exacutus Say
Planorbis sp. (like *parvus* Say)
Valvata tricarinata (Say)
Amnicola emarginata (Küster)
Amnicola sp.
Strophitus rugosus Swainson ? (juvenile)
Sphaerium sp.
Pisidium spp.

Terrestrial species.

Vallonia costata (Müller)
Zonitoides sp.
Gonyodiscus cronkhitei anthonyi Pilsbry
Succinea retusa Lea

17. Lavenham, Manitoba.

One-half mile to the north of the sand bed near Lavenham, from which fossils have been reported above (No. 10), the Assiniboine River has cut a vertical section through greyish silts which have evidently been laid down by the stream in previous times. At least eight species are found in this silt, as follows :—

Limnaea sp. (juvenile)
Planorbis sp. (like *parvus* Say)
Pisidium sp.
Vallonia costata (Müller)
Zonitoides sp.
Retinella hammonis (Strom.)
Gonyodiscus cronkhitei anthonyi (Pilsbry)
Succinea ovalis Say

18. The Pas, Manitoba.

The deposit situated on the bank of the Pasquaia River near the town of Le Pas has already been described above. For the sake of completeness the list of species is repeated here :—

Limnaea stagnalis jugularis (Say)
Limnaea vahlii (Möller)
Limnaea caperata Say
Limnaea sp. (distinct from *vahlii* ?)
Planorbis trivolvis Say
Planorbis sp. (distinct from above)
Planorbula campestris Dawson
Valvata lewisi Currier
Musculium sp.
Planorbula sp. (distinct from above)
Physa gyrina Say
Aplexa hypnorum (Linné)
Retinella hammonis (Strom.)
Zonitoides nitida Müller
Gonyodiscus cronkhitei anthonyi (Pilsbry)
Succinea ovalis Say
Succinea avara Say

19. Paskwegin, Saskatchewan.

Excavations on the shore of Little Quill Lake at a point situated four miles south of Paskwegin siding (Canadian National Railways) and half a mile east of Stony Point resulted in the discovery of large shells of *Lymnaea vahlii* together with plant remains (probably *Scirpus* and *Typha*) two feet under the surface. These deposits are undoubtedly of very recent origin, and must have been laid down during a period when the level of the lake was several feet lower than at the present time and what is now the shore-line was occupied by marshes.

20. PASKWEGIN, Saskatchewan.

Along the shore of Little Quill Lake near Rocky Point, which is somewhat more than a mile to the west of Stony Point, and five miles south of Paskwegin siding (Canadian National Railways) there are in places small ridges of laminated sand which, in 1928, were being eroded by wave action. These deposits presumably were laid down by the waters of the lake at some recent period when the level of the water stood considerably higher than at present. It may be noted that such oscillation of the level of the waters of this lake is well known in this district. The examination of a well-marked and relatively ancient beach of the lake situated approximately one mile and a half south-west of the village of Wadena, Saskatchewan, and several miles from the present shore-line of Little Quill Lake, failed to reveal any evidence of molluscan fossils. The species found in the Rocky Point beds of laminated sands were :—

Limnaea sp.
Planorbis sp. (like *parvus* Say)

21. FORT GARRY, Manitoba.

The flood plain of the Red River at a point situated four miles south of the limits of the city of Winnipeg was examined in 1925 shortly after the spring freshet, when the annual flood had subsided. The shells of three species of fresh-water mollusca, namely, *Limnaea vahlii* (Möller), *Valvata tricarinata* (Say), and *Sphaerium* sp., were found in the material which had been deposited by the flood waters of the spring of that year. These shells may quite properly be regarded as fossils, and are included here in order to emphasize the fact that the post-glacial fossil molluscs and those living at the present time are really both members of one fauna.

It is suggested that this concept of the extremely gradual transition from the fauna of one age to another might be a useful one to keep in mind in the study of the evolution of such a group as the mollusca. This is especially so since students of palaeontology sometimes tend to emphasize the significance of a sudden change in the conditions of life from one geological period to another.

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REVIEW.

The Katamorphism of Igneous Rocks under Humid Tropical Conditions. By Sir John Burchmore Harrison, C.M.G., pp. 79. Published by the Imperial Bureau of Soil Science, Rothamsted Experimental Station, Harpenden, 1934. Price 5*s*.

THIS is a posthumous publication of a manuscript compiled before 1921 by the late Professor Sir John Harrison. All those who are interested in the weathering of igneous rocks and in soil formation will be very grateful to Sir E. J. Russell, Director of the Imperial Bureau of Soil Science, for making it available, and to Professor F. Hardy, of the Imperial College of Tropical Agriculture, Trinidad, for his revision of the manuscript and for his preface.

The volume contains Sir John Harrison's own account of his work on soils and rock weathering in British Guiana; if he wrote more than the volume contains, it cannot be found; but what it does contain is of great value, being the discussion of a large number of chemical analyses of rocks and waters and the author's deductions from them, together with descriptions of thin sections.

The author insisted on the importance of chemical analyses and mineralogical investigation of thin layers, working upwards from the unaltered parent rock to the final surface soil. The results given are chiefly based on such serial investigations, but some sections of the volume deal with other matters. For instance, on pages 59 and 60 is a very interesting section on the katamorphism of muscovite in which the author concluded that, although muscovite is generally described as offering great resistance to weathering, it is in British Guiana broken down to an argillaceous mixture of kaolin or halloysite with shreds of unaltered or partly altered muscovite and limonite. On page 65 again is an important conclusion which accords with the later work of C. S. Ross and P. F. Kerr

(*The Kaolin Minerals*, U.S.A. Geol. Survey, Professional Paper 165-E., 1931, 176), and is worth quoting in full: "Thus the disintegrating and kaolinizing granite does not afford to petrographic examinations of the slices any evidence of a change during weathering to gibbsite or to a hydrous mica, such as sericite, although a sericitic mica is present in places with chlorite as an alteration product of the biotite of the original rock. The katamorphism of this granite under tropical conditions, and in a position where basic lime-soda rocks would undergo lateritization with products of gibbsite, is confined to the surface of the alkali-felspar, and appears to result only in the production of an amorphous product, either a kaolin or a close ally thereof."

The author avoided questions of terminology as much as possible, but could not escape definitions (page 10), and there we find that he confined the term "laterite" to the residual deposits of more or less basic rocks weathered in situ and characterized by the occurrence in or upon them of highly ferruginous or aluminous concretions, with, in some cases, secondary silicates. The reviewer respects the author's wish to avoid discussion of terminology by refraining from comment.

The conclusions to which the author was led are given in summary on pages 9 and 10. The most important are that under tropical conditions basic and intermediate rocks leave on weathering a residuum of aluminium trihydrate, limonite, in some cases secondary quartz, and the resistant minerals of the parent rock, this residuum being termed "primary laterite"; that the process of primary lateritization is succeeded by one of resilication; that on the other hand acid rocks do not undergo primary lateritization, but gradually change into products consisting largely or mainly of hydrated aluminium silicate, more or less quartziferous and impure kaolins; but the author adds that under tropical conditions lateritic earths (laterite with secondary hydrated aluminium silicates) and even pot-clays (kaolins) may undergo desilication with the formation of bauxite. As Professor Hardy remarks in his preface: "In recent years many of Harrison's observations and deductions have been substantiated and confirmed by other workers in various parts of the tropics . . ." It is comforting to the reviewer to find that support of his views existed so long ago and he is encouraged to hope that now the conversion of sceptics may be rapid.

A further conclusion stated by the author (page 10) is that in temperate climates the katamorphism of basic rocks is not lateritic "but a gradual and less complete process resulting in the formation of more or less complex hydrated silicates"; and he thought that this difference explained the alleged low fertility of tropical soils formed from more or less basic rocks and the fertility of such soils in temperate conditions. In Malaya, however, soils formed from basic and intermediate rocks are sought after on account of their fertility and the author does not give analyses in this volume supporting his conclusion.

Professor Hardy has presented the author's results in an admirable manner, but he might have carried his revision a little farther to eliminate such terms as " pot and pipe-clays ", " muscovite mica ", " biotite mica ", and above all the word " acidic ", which may find favour in the New World, but certainly is not English. On the other hand, we are told that the author never used the terms " pedogenic processes " and " podsolization ", for which we may be grateful.

J. B. S.

CORRESPONDENCE.

ON THE MARINE GRAVELS AT MARCH, CAMBRIDGESHIRE

Sir,—Owing to my absence abroad I did not see the proofs of the part for which I was responsible of Mr. Baden-Powell's paper in the May, 1934, number of the Geological Magazine ; a rather large crop of errors and misprints having crept in, I shall be glad of space to correct these, as follows :—

		Silt.	*Gravel.*
		B.	D.
p. 201.	*Reussella spinulosa* var. *glabrata* . .	I	—
	Bolivina dilatata Reuss ?	I	—
	for *Bulumina* read *Bulimina* (three times).		
	for *Virginulina* read *Virgulina.*		
	for *Crassidulina* read *Cassidulina.*		
	for *Marginula* read *Marginulina.*		
p. 202.	below *Pseudotextularia globulosa* insert :—		
	Pleurostomella subnodosa (Reuss) . .	—	I
	for *Cristalleria* read *Cristellaria* (three times).		
	for *Bulumina* read *Bulimina.*		
	for *Globigerina aspersa* read *Globigerina aspera.*		
p. 203.	for *Lagena williamsomi* read *Lagena williamsoni.*		
	for *Lagena laevigata* read *Lagena lucida.*		
	for *Reussella spinulosa* var. *glabra* read *Reussella spinulosa* var. *glabrata.*		
	for *Cristalleria* read *Cristellaria.*		

W. A. Macfadyen.

Iraq Geological Department,
Baghdad,
25th June, 1934.

The late Professor J. E. Marr was born in 1857, at a house in Morecambe Terrace, Poulton-le-Sands, as it was then called, now part of the Borough of Morecambe and Heysham. The Corporation of the borough have now placed on the house a memorial tablet, which was unveiled on 23rd June last by Mrs. Walker-Jones, his last surviving sister. Professor Sir F. Gowland Hopkins, President of the Royal Society, spoke on the work of Professor Marr as a geologist and afterwards the company was entertained to luncheon by the Mayor, Aldermen, and Councillors of Morecambe and Heysham.